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Teacher Certification

The two national organizations primarily concerned with teacher certification are the National Association of State Directors of Teacher Education and Certification and the National Commission on Teacher Education and Professional Standards. The State Directors are responsible for granting teacher certificates and supervision of teacher education in the states. State Directors, professors of education, administrators, and teachers in elementary and secondary schools attended the recent annual meeting of the National Commission. Members of academic departments in colleges and universities were notably absent, not because they would not have been welcome, but because in recent years they have not been active in teacher certification.

At one session of the State Directors' meeting, papers were presented by representatives of the Modern Language Association, the American Historical Association, and the AAAS. This session was planned to give academic professional organizations an opportunity to submit their views on teacher certification. One member of the audience suggested that it would be helpful if State Directors could appear on programs of meetings of academic organizations when certification was to be discussed. He referred to what he considered an unfortunate situation in his state when teacher certification had been discussed at an Academy of Science meeting without the presence of any state certification officer. National officers of NASDTEC have encouraged the AAAS to seek the appointment of scientists to teacher certification boards in the 48 states. The June meeting indicated full cooperation by State Directors.

The State Directors passed a resolution disagreeing with a recently published statement that one-third of the states authorize the teaching of mathematics in high school by persons with no college preparation in the field. The resolution expresses concern that such a statement be published before pertinent information had been obtained from appropriate professional agencies. It is true that 17 of the 48 states grant a general teaching certificate, without indication of the subjects the recipient is qualified to teach. In some states this certificate is valid for teaching in either elementary or secondary school. The certificate is issued upon recommendation of an approved college or university which does require a teaching major or minor. Even though the certifying agency considers subject-matter preparation an important part of the qualification for general certification, this practice leaves much to the discretion of the superintendent or principal and lends itself to easy misinterpretation by laymen. The issuing of general certificates raises a problem that needs examination.

The National Commission meeting was organized around four problems to be considered by discussion groups, which were directed to formulate goals for the decade ahead. If any aspect of the discussions might have disappointed scientists, it would have been the hesitancy of classroom teachers to speak for the importance of training in subject matter. One of the most effective ways for scientists to advance the view that subject-matter preparation is exceedingly important for teachers is by their voluntary participation in their state teacher-certification commissions, affiliates of the National Commission. Attendance of a considerable number of scientists at the 1957 annual meeting of the National Commission would also be highly desirable.—J. R. MAYOR, *AAAS Science Teaching Improvement Program.*

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Mechanics of Freezing in Living Cells and Tissues

Harold T. Meryman

Well into modern times, man's interest in biological freezing appears to have been concerned primarily with his defense against it. The vast literature concerning low temperature in biology has been predominantly directed toward the therapy of clinical and experimental cold injury without particular concern for the basic mechanisms of ice formation. Within the last 20 years, the preservation of food by freezing has stimulated much general interest in the potential usefulness of low temperature, but still surprisingly little basic work has been undertaken on the mechanisms involved. The majority of the earlier investigations into biological freezing have been made by a few scattered workers primarily interested in the preservation of tissue cells and microorganisms. The principal impetus to low-temperature biological research came with the availability of liquefied gases in the latter part of the 19th century, after which an infinite variety of tissues and organisms were subjected to freezing and thawing. Primary interest, however, invariably centered about the question of survival, and attempts to construct a picture of the mechanism of freezing and freezing injury were predominantly deductive. To the modern student of this subject, it is somewhat reassuring to find that the major part of the literature on biological freezing is fully as contradictory and confusing as that of any other growing field, indicating that its principles are neither totally self-evident nor without challenge.

In very recent years, the appearance of the biophysicist and the growing appreciation of the basic physical nature of biological phenomena has resulted in a reappraisal of much of the earlier work and the development of new evidence which has led to a considerable clarification of the mechanism of freezing in cellular materials in terms of simple and consistent physical phenomena. The extensive work of Luyet (*1*), with his particular attention to ultra rapid freezing and "vitrification," and the work of Lovelock on the mechanism of slow-freezing injury and glycerol protection (*2–4*) have done much to insert a foundation of theory under the wide-spread but empirical applications of freezing. Sufficient of the principles underlying freezing, freezing injury, and the means for its control are now available so that a reasonably well-integrated picture of the process can be hypothesized.

The existing and potential applications of freezing, both as a means of preservation and as a vehicle for the suspension and study of transient phenomena, are legion. This article is an attempt, not to accumulate in detail the many existing techniques applicable to special problems or to review the literature in its entirety, but to present an integrated hypothesis of the mechanism of biological freezing and the known means of preventing otherwise inevitable damage, with the hope of making more immediately recognizable the potential merit of the biological solid state as a unique and useful research tool.

Physical Principles of Ice-Crystal Growth

Relatively unspectacular for the biologist, perhaps, but nonetheless essential to an understanding of the rules of freezing and thawing, are the general concepts of ice-crystal nucleation and growth. It is these two phenomena that will interact to determine crystal size, a factor of obvious significance in any biological freezing. Only by understanding the factors governing ice-crystal development can we hope to influence them for our own ends. It may perhaps make the following dissertation on crystallization more palatable to the biologist if I point out that the single most important and fundamental concept in biological freezing is that, regardless of the mysterious complexity of the biological matrix, freezing represents nothing more than the removal of pure water from solution and its isolation into biologically inert foreign bodies, the ice crystals. All the biochemical, anatomical, and physiological sequelae of freezing are directly or indirectly the consequences of this single physical event.

The ultimate crystal size is immediately dependent on the crystal nucleation rate and the crystal growth rate. Both of these rates are temperature dependent, and their control is primarily a problem in heat exchange which, in turn, depends upon the thermal and geometric characteristics of the specimen, the temperature and characteristics of the coolant, and the nature of the specimen-coolant interface. All materials possess definite crystal nucleation and growth coefficients which can be changed by altering the composition of the material. In addition, once crystallization has been completed, there remains yet another factor, recrystallization, the growth of large crystals at the expense of smaller, which can radically alter the state of affairs even after the solid state has been achieved.

As will be evident from the more detailed discussion to follow, the various factors influencing crystal development are themselves somewhat controllable, rendering the peculiar problems of biological freezing in turn more amenable to discipline.

Crystal nucleation. A crystal nucleus is an aggregation of molecules that may grow to form a larger crystal. Two mechanisms for the formation of nuclei are presumed to exist (*5, 6*). The first, homogeneous nucleation, results from random fluctuations in the density and configuration of water molecules. A nucleus is said to be of critical size when

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it has an equal chance of growing or diminishing. In thermodynamic terms, this is the size at which the free energy available from the spontaneous transformation is equal to the surface free energy of the nucleus. Under these conditions, the free energy of the nucleus will diminish with either the addition or subtraction of molecules; it is in unstable equilibrium and must grow or vanish. The radius of a nucleus of critical size is directly proportional to the liquid-crystal interface energy and inversely proportional to the liquid-crystal free energy difference. This makes the size of a critical nucleus strongly temperature dependent. At temperatures near the melting point, the critical size becomes very large, approaching infinity at the melting point. As the temperature is reduced below the freezing point, the critical size becomes smaller. Generally, the probability of homogeneous nucleation is very low until rather extreme degrees of supercooling are attained, when the probability rises sharply within the range of a few degrees to very high values. This sharp rise in nucleation rate effectively limits the temperature to which supercooling can be carried. This maximum supercooling temperature, designated by Turnbull (*6*) as $(\Delta T_{-})_{max.}$, generally bears a fixed relationship to the absolute melting temperature, T_0. For water, the experimentally determined ratio of $(\Delta T_{-})_{max.}$ to T_0 is 0.14, placing the limit to which water may be supercooled at $-39°C$ (*7*).

Whereas for most metals crystallization appears to be inevitable once $(\Delta T_{-})_{max.}$ has been attained, for some other substances the rate of nucleation apparently falls again if the temperature passes below this level before crystallization is completed (*7, 8*). The cause of this is not fully clear, although it seems probable that a rapid increase in viscosity may be responsible.

The second means for the formation of crystal nuclei is called heterogeneous nucleation, and is considered to be the result of catalysis by inclusions that presumably provide a substitute nucleus about which further crystal growth may take place. The probability for heterogeneous nucleation is quite poor near the freezing point, so that relatively small volumes (~10 milliliters) can be easily and repeatedly supercooled. The temperature to which any given sample can be repeatedly supercooled has been shown by Dorsey (*9*) to be quite reproduceable and has been called by him the temperature of spontaneous freezing (t_{sf}). These temperatures ranged, for different samples of pure water, to as low as $-20°C$ and at no time was freezing initiated at a temperature higher than $-3°C$. From this evidence it appears that 0°C is not, for water, a consistent nucleation temperature. Supercooling is, then, usually necessary to initiate nucleation but, once having occurred, freezing can then proceed at the conventional freezing temperature. Since homogeneous nucleation is virtually impossible until extreme degrees of supercooling are obtained, heterogeneous nucleation is undoubtedly the dominant mechanism in all freezing of large volumes (*6*).

A reduction in the temperature of spontaneous heterogeneous nucleation (t_{sf}) with the addition of solutes has been shown by Dorsey (*9*), and also by Lusena (*10*), to be of the same magnitude as the reduction in freezing point. No attempt has been made to investigate the effect of solutes on the minimum temperature for homogeneous nucleation, $(\Delta T_{-})_{max.}$

Crystal growth. Companion to nucleation rates in determining crystal size is the velocity of crystal growth. Contrary to intuitive expectations, crystallization velocity, when considered independently from nucleation, does not increase with decreasing temperature but, as demanded by physical theory, crystal growth rates are reduced exponentially with decreasing temperature (*11*).

Thus, when freezing occurs in relatively large volumes (greater than 1 cubic centimeter) at or near the melting point, the principal and perhaps only source of nucleation will be heterogeneous from inclusions. If these are absent or if cooling rates are sufficiently rapid so that crystal growth from a few inclusions is insufficient to prevent supercooling, homogeneous nucleation becomes dominant at a lower temperature. The increase in the number of nucleation centers is further aided by the reduction at low temperatures of the crystal growth rate, encouraging the appearance of new nuclei rather than the growth of existing crystals.

A final landmark in the descending temperature scale is the glassy transformation temperature, roughly $-130°C$, below which ice-crystal growth cannot take place. The only well-documented demonstrations of noncrystalline ice have been obtained by the slow condensation of water vapor on a condenser surface held at liquid air temperature (*8, 12*). These experiments also demonstrated that nucleation and crystallization can occur at any temperature higher than this critical point inasmuch as glass ice, when warmed to $-129°C$, crystallized precipitously (*8*). The attainment of the glassy state through the supercooling of bulk water is extremely difficult if not impossible because of the ease and rapidity with which water is transformed into its low-energy crystal structure. However, once the sanctuary of the glassy transformation temperature has been reached, further change of state cannot occur regardless of the latent instability of the system.

Whereas the creation of pure glass ice is an extremely difficult procedure, it can be achieved without difficulty by the addition of certain compounds that are effective in reducing the crystallization velocity. Tammann and Buchner (*13*) determined the retardation effect of several compounds, and this investigation has been repeated and extended by Lusena (*14*). Both these authors demonstrate that relatively small amounts of certain alcohols, glycols, sugars, and proteins can exert considerable effect on the retardation of crystallization velocities, some reducing it by a factor of 10 at a concentration of approximately 5 percent and, for ethanol, by as much as a factor of 1000 at a concentration of 30 percent. The mechanism of this action is not clearly understood. It is highly unlikely that simple alteration of viscosity could account for the effect. A more plausible suggestion is that these compounds may act as impurities, included in the oriented structure of a growing crystal face by virtue of their bound and electrostatically associated water layers or as interfacial hydrates, creating an obstacle to the subsequent growth of that particular crystal face.

Crystal size. Ultimate crystal size will be inversely proportional to the population density when crystallization is complete. Crystal size is, thus, almost completely dependent on the number of nuclei formed. Since heterogeneous nucleation is temperature dependent, slight supercooling can increase nucleation from this source. If heat is removed from the specimen no faster than it can be supplied by a few growing crystals, the over-all temperature will fall to and remain at the freezing point, at which the probability of further nucleation is at a minimum. Under these conditions, a very few initial crystals can grow to completion without the formation of additional nuclei. If the removal of heat is rapid, new nuclei will be formed at a rate comparable to the degree of supercooling attained through the discrepancy between heat removal and the supply of latent heat and internal energy, which is a function of the specific heat of the material. Thus, with increasing rates of heat loss, increasing numbers of crystals are formed. When (ΔT_{-}) is reached, homogeneous nucleation is dominant. When the glassy transformation temperature is reached, crystallization ceases.

It is apparent, then, that crystal size is ultimately a function of the rate of cooling, and it is to the factors influencing this rate that we now turn our attention.

Rate of freezing. The rate of freezing is defined as the rate of advance of a freezing boundary in a linear direction through the medium. Since this rate and

the rate of cooling and nucleation are inseparably interdependent, we shall consider the rate of freezing as the controlling factor in crystal size. Experimentally, at intermediate rates of freezing, crystal size is found to be approximately inversely proportional to the rate of freezing (*15*). At very low rates approaching those obtained when single crystals are formed or at high rates producing incomplete crystallization, this relationship is obviously inapplicable.

Three physical characteristics of the specimen materially affect the rate of heat transfer and hence the rate of freezing: specific heat, thermal conductivity, and latent heat of fusion. In any nonsteady state, where temperature gradients are changing, specific heat and thermal conductivity become interdependent. As a thermal gradient flattens, internal energy is released at every point, but at a rate depending on its removal by conduction. The amount of heat to be lost depends, in turn, on the specific heat of the material. These two thermal constants (plus density, here of negligible importance) are often included in the single term, *thermal diffusivity*. An example of the significance of this relationship may be seen in the case of water and ice. While the ratio of thermal conductivities between the two is nearly 1/5, the ratio of specific heats is roughly 2/1, indicating that it will be about ten times easier to remove heat from ice as from water (neglecting convection).

The roles of thermal conductivity, specific heat, and latent heat of fusion in determining freezing rates may best be examined by considering separately the phases of a freezing material: the unfrozen interior, the frozen exterior, and the freezing boundary.

If the internal, unfrozen portion is above the freezing point, it will contain heat which must be lost prior to freezing. Since all this heat must pass across the freezing boundary, which is at a fixed temperature, the rate of heat loss from the interior will be wholly independent of coolant temperature or any factors outside the freezing boundary except as they affect boundary advance. The interior, in effect, "sees" only the freezing point as its temperature for eventual equilibration, much as water in a reservoir equilibrates at the height of the dam regardless of the drop beyond. The internal volume of a freezing material will, then, tend to approach equilibrium with the temperature of the freezing boundary. Whether or not it does so will depend on the efficiency of heat removal from the interior (thermal diffusivity) and on the rate of advance of the freezing boundary, which may or may not allow adequate time for internal equilibration.

Within the outer frozen portion of the specimen, a gradient exists between the external surface, at or near coolant temperature, and the freezing boundary at a fixed temperature. Not only must heat from the interior and the freezing boundary be transmitted across this gradient, but, as the interface advances, the distance increases, and the gradient flattens, necessitating the liberation of internal energy from the solid phase and the introduction, again, of thermal diffusivity as a factor.

From the freezing boundary itself originates latent heat of fusion which must pass to the coolant across the solid phase. It is now clear that specimen characteristics will influence the rate of freezing in the following manner: (i) the internal energy (dependent on specific heat) and the rate at which it may be removed from the unfrozen interior (thermal diffusivity), (ii) the amount and rate of production of heat from the freezing boundary (latent heat of fusion), and (iii) the efficiency of conduction of heat from these two sources through the frozen volume (conductivity) plus the removal of heat from the frozen volume itself (diffusivity).

The third major factor influencing rate of freezing is the geometry of the specimen (*15, 16*). A one-dimensional system, in which the freezing boundary advances as a plane front into a solid, shows rate of advance as a square root function of distance advanced. In the case of experimental models, using a dilute starch solution as the specimen, the diffusivity of the unfrozen starch solution is sufficiently poor so that, despite the decreasing rate of boundary advance, the unfrozen portion at no time reaches the freezing point before the arrival of the freezing boundary.

In a two-dimensional case, as exemplified by freezing inward from the periphery of a cylinder, the situation is vastly different from that of an advancing one-dimensional plane boundary. Here, as freezing progresses, the unfrozen portion is being reduced in volume, not linearly, but as the square of the radius, while the area of the freezing boundary is reducing only as a linear function of advance. In other words, as the freezing boundary advances into the cylinder, it receives from the interior and produces itself an exponentially decreasing quantity of heat to be removed to the outside. This, in effect, counterbalances the increasing distance from boundary to coolant. Experimental freezing curves show, for the cylinder, an initial rapid rate, stabilizing to a nearly linear rate of freezing until an acceleration is again observed as freezing is almost complete at the center. It is also interesting to note that, despite the poor diffusivity of the unfrozen interior, the rapid increase of surface-to-volume ratio, $2/r$, with boundary advance permits the interior of the specimen to approach temperature equilibrium with the freezing boundary prior to the arrival of the boundary. This is the cause of the familiar plateau at the freezing point obtained by thermocouple measurement from the interior of a freezing biological specimen.

In a three-dimensional case, freezing inward from the periphery of a sphere, the surface-to-volume ratio becomes $3/r$, and the shape of the freezing curve is similar to that of the cylinder but more rapid in terms of linear advance. Internal temperature equilibration at the freezing point is seen earlier and becomes complete when freezing has progressed only about half way to the center.

The same principles enumerated here for freezing apply equally to thawing. There is, however, one major practical difference: in general, the positions of the high and low diffusivity phases are reversed. Whereas in freezing, heat is released slowly from the internal, low-diffusivity material and rapidly removed through a good conductor, in thawing, heat is easily distributed throughout the internal, high-diffusivity solid but, as thawing proceeds, the heat is provided to the thawing boundary through an inincreasing layer of poorly conducting melt. This is strikingly shown in temperature records obtained from the two situations. In freezing, the boundary moves in rapidly, advancing well into the specimen before equilibration of the interior takes place, if at all. On thawing, heat is rapidly distributed through the volume of the high-diffusivity solid, which equilibrates throughout at the melting point, almost before any melting has taken place. The melting boundary then proceeds into the specimen at a much reduced rate compared with that of freezing. The significance of this difference will become apparent in later discussions of biological applications.

Recrystallization. In addition to the factors operating during the transition from liquid to solid and solid to liquid, there is one more aspect of crystallization that is of great importance in many applications of freezing to biology. This is recrystallization, the phenomenon of preferential growth in the solid state of large crystals at the expense of smaller ones. Recrystallization results primarily from surface energy differences between large and small crystals and to differences in free energy due to internal strain. Although in frozen biological media interfacial energy differences between the crystal and other phases, the intervening viscosity of solutions between crystals, and the complex influence of impurities seriously affect recrystallization rates, they are, nevertheless, still temperature dependent. The recrystallization of pure ice appears to obey the Arrhenius equation for rate processes (*17*).

At very low temperature, recrystallization is relatively slow, and equilibrium is approached while the crystals are quite small. At temperatures near the melting point, recrystallization is rapid, and crystals may grow to nearly visible size in less than an hour. The low temperatures at which significant changes in crystal size can occur are surprising. Electron microscope studies of recrystallization from a noncrystalline ice film show the development of crystals 1 micron long in 30 seconds at −70°C (*17*).

When a complex solution is frozen, each crystal will be surrounded by a layer of concentrated solute that will impede the diffusion of water molecules from one crystal to the next and reduce the rate of recrystallization. Although no figures are available for ice-crystal growth in biological solutions at very low temperatures, Luyet and Gibbs (*18*) describe the development of innumerable microscopic crystals into a single crystal filling an onion root tip cell after 2 hours' storage at −4° to −8°C.

With decreasing temperature, the rate of migratory recrystallization falls, approaching zero at the glassy transformation temperature. For pure ice, this temperature is in the vicinity of −130°C. (*8, 17*). For solutions containing several elements with differing glassy transformation temperatures, the resultant will be approximately the mean of all transformation temperatures corrected for relative concentration.

Freezing in Cellular Biological Systems

One of the most intriguing phenomena of freezing in tissue, or any viable cellular suspension, is the fact that with slow freezing, crystal nucleation is generally confined solely to the extracellular spaces (*19–21*), although Heard reports (*22*) intranuclear crystals in slowly frozen liver. Whether this tendency for extracellular crystallization results from an absence of heterogeneous nucleation sites within the cell or simply from minute differences in freezing point is unknown. It is nevertheless a fact that crystallization is wholly or predominantly extracellular until rather rapid rates of freezing are obtained and nucleation becomes general throughout the medium. It is on this phenomenon that we prefer to base the definition of rapid and slow freezing rather than on some particular, arbitrarily chosen, numerical rate. Subsequent references to slow freezing will indicate conditions under which only extracellular crystallization is obtained; the term *rapid freezing* refers to rates of cooling that are sufficiently high to cause intracellular crystal growth.

The mechanisms of injury by slow freezing and by rapid freezing are considered in detail in subsequent paragraphs. These are followed by an analysis of known means for the prevention of such injury.

Slow freezing. With the formation of an extracellular crystal nucleus and its subsequent growth, extracellular osmotic pressure is increased, and water is withdrawn from the cell and is ultimately added to the growing crystal. The increased concentration of the medium surrounding the crystal lowers the freezing point and hence the local temperature, permitting a lowering of the temperature in advance of the freezing boundary. New nuclei form here, effectively widening the freezing boundary without increasing the numerical density of crystals. The ultimate result is the development of a few large ice crystals that have incorporated all available free water and have relegated the saturated solution of electrolyte, carbohydrate, protein, and other cell constituents, with their "bound" water, to the crystal interfaces.

In most, if not all, soft-tissue cells there is no gross membrane rupture by slow freezing. Even though it is frozen for long periods of time, upon thawing, the water is reimbibed by the cells, and their immediate histological appearance is often indistinguishable from the normal (*21, 22*). More remarkable still, many cells show complete recovery provided that the exposure has not been of excessive duration (*23*). It is therefore apparent that extracellular crystal formation is not per se a uniformly lethal event. The lethal factor, a direct result of crystal formation, is the exceedingly high concentration of electrolyte resulting from the removal of water from solution (*4, 24*). Since this is a biochemical factor, it shows both time and temperature dependency as well as species differences.

Not only is there temperature dependence because of the slowing of chemical rates with reduced temperature but, between 0° and about −10°C, because of both freezing point lowering and the variable degree of binding of water, only part of the freezable water is removed from solution. Lowering the temperature increases the amount of water frozen from as little as 50 to 60 percent at the freezing point to more than 90 percent at −10°C (*24, 25*).

A wide variability exists in the response of different tissues to freezing. While epidermal and muscle cells can withstand mild freezing for an hour or more (*23, 26*), erythrocytes seem to succumb almost instantly (*2*). Lovelock (*4*) considers −5°C as the lowest temperature to which mammalian cells may be slowly frozen and still survive. In any case, the increase in concentration, as temperature is lowered to about −10°C, has far more influence on the rate of biochemical injury than the opposing effect of lowered temperature in reducing biochemical rates.

A hypothetical action spectrum of the rate of injury with decreasing temperature might be expected to appear as follows. (i) With a fall of 1 or 2 degrees below the freezing point, only part of the water has been frozen out and the denaturation from electrolyte concentration is very slow or perhaps nonexistent. (ii) With a further reduction in temperature, more water is frozen out, and the resultant concentration becomes more acute, reaching its maximum somewhere between −5° and −10°C, with a corresponding rapid increase in the rate of production of injury. (iii) If the specimen survives this far, further decrease in temperature causes no further change in the degree of dehydration but simply results in a logarithmically decreasing rate of chemical denaturation, presumably reaching a standstill at the glassy transformation temperature somewhere in the vicinity of −100°C or below.

Reversing the process results in a logarithmic increase in rate of injury with increasing temperature until the vicinity of −10°C is reached. Here it appears that there may be some hysteresis of the action spectrum (*27*). That is to say, at −4°C, for example, 10 percent of the freezable water in a given system may have remained liquid during freezing because of some sort of adsorption or binding. However, once frozen, it will not necessarily return to the liquid state upon being raised again to −4°C. Thus, the degree of dehydration and the rate of injury therefrom may be far greater at temperatures between 0 and −10°C upon warming from a lower temperature than they were during the initial freezing.

Thawing can thus affect the slowly frozen tissue in two ways. (i) Exposure to high electrolyte concentration at high temperature will produce a high rate of injury, particularly if an action spectrum hysteresis such as suggested in the previous paragraph exists to a significant degree. (ii) A prolonged exposure at higher temperatures may permit the growth of ice crystals by recrystallization prior to actual melting, although, in view of the apparent inoffensiveness of the large extracellular ice crystals to begin with, their slow redistribution is probably equally innocuous.

Identical reasoning applies to the question of storage temperature. Crystal growth through recrystallization will presumably be of little consequence because of the extracellular position of the crystals. The deleterious effects of storage can be attributed primarily to the biochemical process of dehydration denatur-

ation. This, being temperature dependent, reduces in rate exponentially with temperature decrease, presumably reaching zero rate at the glassy transformation temperature.

It should be pointed out that there is at least one situation in which the phenomenon of extracellular growth with slow freezing does not occur. Cells that have been frozen under conditions known to be lethal do not show a preferential extracellular crystallization on a second freezing, but crystallize uniformly throughout with the growth of large, destructive intracellular crystals (*21*). (This is one reason for the familiar advice on frozen foods, "do not refreeze.") Whether this is simply a reflection of loss of viability and membrane permeability or of some more subtle effect of freezing per se has not been experimentally investigated.

Rapid freezing. When the rate of freezing becomes sufficiently rapid, the tendency for preferential extracellular nucleation is subordinated and nuclei appear uniformly throughout the specimen, forming crystals that are predominantly intracellular. The rates of freezing necessary to achieve this condition are quite high, producing crystals which are small and numerous. Experimental freezing in rabbit liver showed that, when freezing was rapid enough to introduce intracellular crystals, the crystal size had been reduced to about twenty microns (*21*).

Whereas, with slow freezing, the physical presence of the extracellular crystal appears to be of minor significance, an intracellular crystal created by rapid freezing cannot be dismissed so casually. If its size exceeds that of the cell which contains it, the result is obvious. The size which it can attain within the cell without exerting lethal trauma has not been determined, but it is clear from the few records of successful rapid freezing that the rate must be extremely high and the crystal size extremely small for the result to be completely benign (*28, 29*).

In the addition to the lethal potential of intracellular crystal growth, rapid freezing also creates a dehydration with the same potential for denaturation as that responsible for injury following slow freezing. This being the case, the same concern over rates of denaturation will also influence the choice of storage temperature. It is impossible, as yet, to state with assurance whether the limitation in the choice of storage temperature will be because of crystal growth or dehydration denaturation. In all probability this will involve a substantial species factor, in which cells resistant to dehydration will succumb principally to crystal growth and vice versa. In any case, this represents one of the restrictions of the rapid-freezing technique, in which storage can be conducted satisfactorily only at very low temperatures, certainly below $-50°C$, where crystal growth and biochemical denaturation are minimized.

The rapidity with which destructive ice crystals can grow in the solid state renders the thawing procedure equally, if not more, demanding than the freezing procedure. This is particularly true in view of the observations that both denaturation and crystal growth rates increase exponentially with temperature and that, as discussed previously, the kinetics of heat exchange during thawing are far less favorable than they are during freezing. The many experiments of Luyet (*1, 28*) and others (*26, 29*) demonstrate beyond question that very rapid thawing is essential to survival after rapid freezing.

One extreme subdivision of rapid freezing which has been extensively investigated by Luyet (*1*) is the attainment of cooling rates sufficiently rapid to avoid any crystallization whatsoever. This achievement, vitrification, is extremely difficult to attain, not only requiring the ultimate in small specimen size and favorable geometry, but the addition also of compounds designed to shrink cells and bind water. Inasmuch as Luyet's ultimate criterion of noncrystallinity has been optical isotropy as demonstrated by polarized light, crystals smaller than a few tenths of a micron may not have been detected in his apparently vitrified specimens. While it may be true that some organisms can withstand rapid freezing only if crystallization is wholly prevented, it has at least been shown that total vitrification is not a mandatory prerequisite for the survival of mammalian erythrocytes. X-ray diffraction studies of rapidly frozen blood show crystallization to be present, although survival of the cells is not affected (*29*).

If true vitrification were necessary for the survival of certain specimens, the upper limit for storage would then be sharply limited by the glassy transformation temperature, below which the vitreous state is stable and above which crystallization goes precipitously to completion in the form of numerous and extremely small crystals (*8*). The requirements for the thawing of vitreous specimens without permitting crystallization would be extremely stringent.

Practical Application of Freezing to Preservation

Slow freezing. As discussed in previous paragraphs, the principal cause of injury from slow freezing is not the physical presence of extracellular ice crystals, but the denaturation incurred by the dehydration resulting from the incorporation of all free water into ice. To prevent this injury, there appear to be only two alternatives. First, if we presume that the brief exposure to initial freezing can be tolerated, the temperature may be reduced immediately after freezing to very low, stabilizing temperatures. With some cells, such as erythrocytes, this is not practical since destruction is virtually immediate once dehydration has reached a critical level. With other cells that will survive slow freezing for brief intervals, this technique appears to have been successfully applied by the storage at dry-ice temperature of many organisms and tissue specimens in which the survival of isolated individual cells is acceptable.

A second alternative is to prevent a lethal degree of concentration by reducing the amount of ice that forms. This is the basis for the use of glycerine. Most sugars and glycols are strong hydrogen bonders and are efficient binders of water. One mole of glycerine will prevent approximately 3 moles of water from freezing. The addition of glycerine or any other efficient, nontoxic binder that will pass through cell membranes (*30*) to a biological solution reduces the amount of water available to crystallize and hence limits the degree of dehydration produced. As pointed out earlier, some dehydration is compatible with survival; hence it is unnecessary to tie up all the water. The relationships between glycerine, freezing temperature, salt concentration, and survival have been completely determined for erthrocytes by Lovelock (*3*). Not all cellular materials will withstand freezing even in the presence of glycerine. In many cases it is the glycerine itself which becomes toxic in concentrations sufficient to protect against freezing.

Even when immediate denaturation is prevented by reducing dehydration with glycerine, there is still a slow decay in viability, perhaps again the result of the glycerine itself which, because of its properties as a strong hydrogen bonder, may denature protein directly (*31*). This effect is, like any other biochemical process, temperature dependent and can be retarded by lowering the temperature; it eventually becomes negligible at temperatures around $-80°C$ or below.

With the glycerine method, the rate of thawing is of little significance since the crystal size has already approached its maximum and since dehydration denaturation has been prevented with glycerine. An excellent discussion of this technique, as well as an extensive review of the literature of low-temperature biology in general, has been prepared by Smith (*32*).

Rapid freezing. There are three re-

quirements for successful preservation by the technique of rapid freezing: (i) very rapid freezing, (ii) low-temperature storage, and (iii) very rapid thawing. Most of the failure of past efforts to obtain survival after rapid freezing can be attributed to insufficient recognition of one of these requirements. It is not enough that a specimen be plunged into liquid air; it must also be of such geometrical form that uniformly rapid freezing throughout the specimen is permitted. Luyet has attained this by the use of thin films on a cover slip or supported by a wire loop (*1, 28, 33*). In our laboratory, we have found the very small sphere formed by spraying from a rapidly oscillating jet to be more amenable to quantity production in the freezing of whole blood and other suspensions (*34*). In any case, the attainment of a favorable surface-to-volume ratio is of paramount importance. The upper limit of size in the freezing of whole blood appears to be a sphere of nearly 1.0 millimeter diameter. It should be pointed out, of course, that it is never possible to distinguish between the trauma of freezing and the trauma of thawing when survival is the criterion of success. It may well be the adverse heat-exchange relationships during thawing which are the real limiting factors in specimen size.

Experience with the rapid freezing of blood has shown that even the best attainable heat-exchange relationships are often not sufficient to permit 100-percent recovery of intact cells. Fortunately, of the several compounds mentioned previously which are effective in retarding crystallization, several are nontoxic as well as freely transportable through cell membranes. Dextrose, in particular, has been found to be extremely effective in improving the recovery of rapidly frozen erythrocytes.

There appears to be considerable limitation in the choice of the coolant in which the freezing is done. Adequate heat exchange can be achieved only through the use of a liquid coolant at very low temperature, virtually limiting the choice to liquefied gases. The most popular gas, nitrogen, is unfortunately one of the least efficient since, being easily available only at its boiling point, it can acquire heat from the specimen only by vaporizing; in so doing, it forms an insulating gas layer around the specimen. Other gases, particularly propane, methane, ethane, and ethylene, are far more efficient when cooled to very low temperatures because of their relatively high boiling points. The freezing of a thin film or small droplet in propane at −195°C appears almost instantaneous to the eye. However, the diffusion of the coolant into the specimen is extensive, and large amounts of coolant gas are evolved on thawing even after prolonged exposure of the frozen specimen to high vacuum. In the case of blood, no cells survive freezing in coolants other than liquid nitrogen or liquid air.

The assumption that it is the diffusion of toxic gas into the specimen which is responsible for its destruction is not entirely conclusive since there is also evidence that there may be such a thing as too rapid freezing. The use of centrifugal force to accelerate the evolution of gas during freezing in liquid nitrogen presumably improved the rate of freezing but resulted in decreased survival of erythrocytes (*34*). There are reports in the literature of a phenomenon which has been termed "thermal shock" wherein rapid change of temperature *above freezing* results in destruction (*32*). Lovelock (*35*) proposes that this is due to differential thermal expansion between structural components of the cell. It is wholly plausible that, on rapid freezing, the rapid temperature change *prior* to freezing becomes lethal if the rate of thermal expansion exceeds the rate of relaxation permitted by the modulus of elasticity of cellular components. It is unfortunately impossible to cool slowly first, then freeze, since, in order to avoid the dominance of heterogeneous crystal nucleation from catalytic inclusions, the specimen must be rapidly supercooled to near −40°C to initiate homogeneous nucleation before other crystal growth can take place. This supercooling can be accomplished only by extremely rapid heat exchange which may, in itself, be a source of thermal shock. Lecithin is reported to alleviate thermal shock (*32*).

Storage of rapidly frozen specimens will be successful only if carried out at a temperature below that at which ice crystals can grow to lethal size or denaturation proceed at an appreciable rate. For mammalian erythrocytes, the minimum useful storage temperature appears to be roughly −60°C (*34*). Above this temperature, hemolysis develops rapidly. Luyet (*36*) has shown that the rate of hemolysis increases continuously with temperature increase and that there is no discontinuity at any fixed temperature. It is impossible to interpret this initial data as indicating either crystal growth or denaturation as the primary cause of injury. Future studies of the storage of cells known to be resistant to dehydration may shed more light on this question. Regardless of the maximum storage temperature, further reduction effects rapid improvement in results because of the direct logarithmic relationship between temperature and the rate of both crystal growth and biochemical denaturation. Under any circumstances, storage in liquid nitrogen, at −197°C can be considered as essentially indefinite.

Thawing, following rapid freezing, has been shown to be a very demanding procedure. It seems highly doubtful that there is anything analogous to thermal shock which might place an upper limit on the rate at which heat could be exchanged in this direction. In any case, the problem of getting heat into a specimen is such that excessive rates are presently far from realizable. Heat exchange by conduction from a warm liquid appears to be the only immediately practicable procedure. However, the liquid cannot be warmer than the upper limits of biological temperature, generally around 50°C. This is very disadvantageous because, when the specimen is approaching equilibration at the melting point, it is in the most lethal temperature range; more than half the total heat to be exchanged is still represented by its latent heat of fusion, and the temperature differential is only about 50°C. Where the specimen is semisolid, as a tissue, a large volume of well-agitated warming bath is easy to provide. Where a specimen such as blood cannot be diluted or even excessively agitated, the problem of maintaining the maximum possible temperature without exceeding it becomes acute.

The use of means of thawing other than simple conduction have been explored. The nonuniformity of radiant heat makes it difficult to melt all the specimen without overheating what has already melted because of the relatively poor conductive redistribution of the heat put in during the short thawing period. It is estimated that, for blood, 1 second is certainly the upper limit for the total allowable duration of thawing. Microwave heating would appear to offer an excellent solution except for the unfortunate fact that the absorption of energy by water is several thousand times that by ice at currently available frequencies. With this technique, the problem of timing to thaw a specimen in 1 second without boiling it in the ensuing millisecond would be nearly insoluble, even assuming that all portions completed thawing at exactly the same instant. The successful development of a technique other than simple heat exchange by conduction would probably extend considerably both the size and species range amenable to rapid freezing.

In many cases, particularly where more complex organisms or tissue cells are to be frozen, it is mandatory that some additive be incorporated to prevent injury to the cell by rapid freezing and thawing. These materials are not always identical to those useful for slow freezing. Whereas the glycols, particularly glycerine, have been found superior for preventing injury during slow freezing, glycerine is nearly valueless in aiding the recovery of red blood cells after rapid freezing, while glucose and other hexose sugars, urea, and sodium citrate have provided sub-

stantial benefit (*34*). Luyet, on the other hand, found glycerine greatly superior to glucose or sodium chloride in protecting chick embryo heart from damage by rapid freezing (*37*). Three possible mechanisms of protection suggest themselves: (i) a viscosity increase, retarding diffusion of water during freezing and creating smaller crystals; (ii) "binding" of water, reducing the total amount of ice formed; and (iii) reduction in crystal growth rate, permitting the nucleation of additional crystals with an ultimate smaller size (*14*). Regardless of the specific additive, it appears essential that it penetrate the cell and, of course, that it be nontoxic. Some shrinkage of the cell also seems to be useful provided that this is not in itself deleterious.

Discussion

Slow freezing, where possible, is probably the more practicable technique. Crystals are allowed to grow extracellularly and dehydration denaturation is prevented with an additive, usually glycerine. The technique is obviously restricted to those specimens in which rather high glycerine concentrations are tolerated. Any situation in which extracellular crystals are mechanically injurious is also obviously incompatible. The introduction of glycerine into a specimen is relatively simple. Since glycerine exerts little or no osmotic effect, it should be used in an isotonic saline solution. Freezing should be very slow to prevent the accidental initiation of intracellular crystals and to permit the constant readjustment of osmotic pressures as water is frozen out of solution. Although the requirements for storage are not terribly demanding—any commercial freezing unit is satisfactory—for long storage, temperatures in the dry-ice range or lower are advisable to reduce slow decay to a minimum. Subsequent removal of the glycerine by dialysis is a time-consuming and exacting procedure but generally necessary following thawing.

Rapid freezing has the major disadvantage of requiring a division of the specimen into particles of extremely small size in order to achieve rapid heat exchange. Storage must be at least at dry-ice temperature and, for some materials, possibly much lower. Whereas temporary temperature increases above this range are tolerated by specimens that are slowly frozen with glycerine, even momentary rises are destructive to the rapidly frozen specimen. The technique and the equipment are not excessively demanding. Good quick freezing can be achieved by squirting a suspension from a syringe through a very fine-gage needle onto the surface of liquid nitrogen or liquid air. The needle and syringe should be rapidly oscillated back and forth to break up the droplet pattern. The frozen droplets may be subsequently thawed by sifting them into a warm saline solution.

The use of thin films is also a satisfactory method of obtaining rapid heat exchange. This method has the drawback, however, that the specimen cannot be removed from the film support since this requires fracturing the frozen film. All structures lying in the path of the fracture will be destroyed.

The use of some additive designed to shrink the cells and, more important, to pass into the cell and exert a specific effect through the binding of free water and the reduction of crystallization velocities is a useful device for improving the results of rapid freezing. In fact, in more complex organisms and tissue cells, it appears to be essential. A great deal of work on this subject has been reported by Luyet and his associates, who have demonstrated the survival of a wide variety of viable entities following rapid freezing and thawing, usually in the presence of ethylene glycol (*38*). Many of the recent achievements of rapid and of glycerine freezing, including the rapid freezing of whole blood, have been substantially antedated by modest reports from Luyet's laboratory, which, over the last several decades, has produced a wealth of valuable and important experimental data.

Slow freezing, with glycerine protection, has attracted considerable interest in the last few years, and its practicality and usefulness in many applications have been well demonstrated (*32*). Examples of the successful application of rapid freezing to living entities more complex than bacteria are few and isolated, stemming primarily from Luyet and his associates (*33, 39*). Instances of failure to obtain survival of mammalian cells after rapid freezing are also to be found (*40*), although it is not yet clear whether this failure resulted from injury by thermal shock, as suggested by the author, or is simply a confirmation of the difficulty of meeting the stringent heat-exchange requirements.

There are indications that the use of glycerine and related compounds may significantly extend the applications of rapid freezing while requiring lower concentrations of these additives than would be necessary with slow freezing. These two techniques, glycerine and rapid freezing, should not be considered as in any way independent or competitive since, in all probability, combinations of the two will greatly extend the range of each into areas otherwise denied to both.

With the advent of increasing information regarding the mechanism of freezing and freezing injury, the usefulness of low temperatures in biology should experience considerable development. Whether through the medium of slow freezing with glycerine, rapid freezing, or combinations of the two, low-temperature biology offers exciting potentialities for biological research, not only for the purpose of indefinite preservation, but to provide a true state of suspended animation for the study of transient phenomena which can in this way be interrupted and immobilized for biological eternity in the solid state.

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Federal Support of Research in the Life Sciences

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Since the postwar entry of the Federal Government into the financial support of scientific research, there has been a welter of conjecture regarding the level of federal support of research in the life sciences. Many estimates have been made to suit whatever immediate purposes were at hand, so that now it is possible to find appropriate quotations supporting almost any thesis one might wish to discuss: that federal grants and contracts for research in the life sciences are too few, too many, or just about right in number, that they are concentrated in a few specialties, or that they neglect certain important fields. The National Science Foundation early realized the need to collect certain basic factual data that would indicate the extent and nature of the activities of the Federal Government in the life sciences. As a result, the foundation recently compiled and published a listing of federal grants and contracts in the life sciences for the fiscal year 1954 (1 July 1953 to 30 June 1954) (*1*).

The objectives of the compilation were to publish a guide to federal activities in the life sciences for use by science administrators and to assemble fiscal data to determine the magnitude and distribution of federal support to the various areas in the life sciences. This article endeavors to summarize some of the information obtained from the study (*2*). Since comparable but less comprehensive data are available from a study of the calendar year 1952 (*3*), some comparisons between the two periods are included.

Two somewhat similar studies have been made by Deignan and Miller (*4*). Their coverage of the federal program was less complete than that of the present report, but their data did include the program activities of the major private foundations. The classification system they used to categorize the research projects was organized around the major diseases and organ systems and was therefore mainly medical in emphasis. This study takes a different point of view. We have taken cognizance of the major basic biologic disciplines and have recognized medical and also agricultural research as major components of applied biology.

The information on which this paper is based covers the unclassified research and related activities in the life sciences supported by federal grant and contract programs. The report does not include data on research done in Government laboratories except in the rare instances of grants made by one agency to another. It does not include the federal fellowship and scholarship programs. It does not include the federal programs that support the psychological sciences except for a few projects in which the physiological emphasis was significant. The fiscal data are recorded as annual rates of support as of the end of the year reported; they are not necessarily synonymous with either obligation or expenditure data used in other types of federal reports. The 1954 study is thought to represent a coverage of at least 95 percent. It is virtually complete for the agency programs covered, but a few programs are known to have been missed. The 1952 study is probably no more than 85 percent complete.

Distribution by Agency

Table 1 gives the distribution of federal funds by agency. In fiscal year 1954 the Federal Government supported approximately 8100 projects in the life sciences at a total annual rate of $64.5 million. Allowing for the incompleteness of coverage in the 2 years, this represents an increase in funds of about 25 percent over calendar year 1952. In both years, nearly one-half of the total federal support came from the Department of Health, Education, and Welfare (DHEW). The Department of Defense (DOD) was next, accounting for approximately 20 percent. Following in descending order were the Department of Agriculture (USDA), the Atomic Energy Commission (AEC), the National Science Foundation (NSF), the Tennessee Valley Authority (TVA), the Veterans Administration (VA), and the Department of the Interior (USDI). A comparison of distribution during the two years shows that the funds for the Air Force (USAF), the Department of

Table 1. Distribution by agency of federal grants and contracts for unclassified research in the life sciences. The coverages for calendar year 1952 and fiscal year 1954 are estimated to be 85 and 95 percent, respectively.

Agency	Calendar 1952			Fiscal 1954		
	No. of projects	Annual rate (thousands of dollars)	Percentage of total funds	No. of projects	Annual rate (thousands of dollars)	Percentage of total funds
USDA						
OES	3138	9,894.0	21.2	3165	10,207.3	15.8
ARS				36	360.6	0.6
AEC*	314	5,345.0	11.5	377	6,183.5	9.6
DOD						
USA						
ACC				39	696.7	1.1
SGO	318	5,125.0	11.0	398	6,502.2	10.1
OQMG				123	1,629.9	2.5
USN†	342	3,207.0	6.9	427	3,326.4	5.2
USAF‡	77	1,398.0	3.0	142	2,371.3	3.7
DHEW§	2080	20,889.0	44.8	3091	31,249.7	48.4
USDI						
F&W				6	101.4	0.2
BuR				6	21.4	0.0
NSF	131	770.0	1.7	292	1,543.3	2.4
TVA				21	186.3	0.3
VA				21	152.9	0.2
Totals	6400	46,628.0	100.1	8144	64,532.9	100.1

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Health, Education, and Welfare, and the National Science Foundation increased proportionately much faster than those for the other agencies. The Air Force increase may be partially the result of better coverage for the second year, but the other two increases were real. The other agencies all showed some increase, but for the Department of Agriculture and the Navy (USN), the increase was very small.

Categories

A desire to determine the scope and diversity of federal support for the life sciences led to an analysis by the category system defined in Table 2. The system was designed so as to recognize the major basic biological disciplines and the major categories of applied research. The classification includes seven basic disciplines (a somewhat modified version of the arrangement suggested by Weiss (see Waterman, *5*), four categories of applied medical research, three categories of applied agricultural research, one category of technologic research, and five interdisciplinary categories that cover activities related to research but not necessarily confined to one discipline. Categorization was done from short summaries prepared by the principal investigators except in a few cases in which only the title was available. Most of the abstracts were obtained from the Bio-Sciences Information Exchange of the Smithsonian Institution, but others, notably those of the Department of Agriculture, were made available directly by the agency. Each project was uniquely assigned to one category. Since not all research projects were easily assigned to a single category, a sizable subjective element was present in this process. It was especially difficult to distinguish between basic and applied research. The particular slant the investigator chose in preparing his abstract was in many cases the most important factor that determined the category into which the project was pigeonholed. These difficulties should be kept in mind when one draws conclusions from the present data.

The distribution of funds by category for fiscal year 1954 is presented in Table 3. The two categories that received the largest proportion of funds were regulatory biology and pathology, each accounting for approximately 19 percent of the total. Plant management, on the other hand, included a greater number of projects. Among the basic categories, systematic and structural biology received the least support. The most expensive research, on a per project basis, was in the medical sciences, particularly in pathology, therapy, and community health. This will surprise no one who

Table 2. Definitions of categories used to classify federal grants and contracts in the life sciences.

Category	Definition	Examples of pertinent disciplines
Molecular biology	Biology at the molecular level: isolation, structural analysis, synthesis, and reactivity of biological substances, and so forth	Biochemistry, biophysics, biomathematics, biokinetics
Regulatory biology	Regulation of living processes: metabolism, circulation, immunological response, photosynthesis, role and function of biocatalysts, and so forth	Biochemistry, physiology, endocrinology, pharmacology
Structural biology	Physical structure of biological units: subcellular entities, cells, tissues, organs, organ systems, and organisms	Cytology, histology, anatomy, physical anthropology
Genetic biology	Action and behavior of genes and chromosomes, nature and origin of inheritable characteristics and variations, cytoplasmic inheritance	Genetics
Developmental biology	Growth and differentiation: reproduction, fertilization, growth and reproduction of subcellular units and of cells, morphogenesis, regeneration, senescence	Embryology, experimental morphology, gerontology, oncology
Environmental biology	Interrelationships between organisms and external conditions: effects of chemical, physical, and biological factors on activities, distribution, and survival of organisms; commensalism, symbiosis	Ecology, population dynamics, gross radiation effects
Systematic biology	Kinds of organisms: description, classification, biologic relationships of categories, life cycles, evolution, and so forth	Taxonomy, paleontology, phylogeny, zoo- and phytogeography, natural history
Pathology	Description of the cause, course, and results of disease pertaining to human beings	Pathologic physiology and anatomy, medical bacteriology, immunology
Diagnosis	Recognition and identification of disease pertaining to human beings, including mental disease	Internal medicine, neurology, electroencephalography, cardiology, radiology, diagnostics, clinical testing, psychiatry
Therapy	Treatment of disease and disorders pertaining to human beings	Internal medicine, neurology, pharmacology, physical therapy, surgery, psychotherapy
Community health	Health of groups or individuals: control of contagion, pollution, food and drug supplies, occupational and military hazards; chemical, radiological, and biological warfare protection	Public health, epidemiology, sanitation, toxicology
Plant management	Breeding, cultivation, production, and use of economic plants, their diseases and pests	Plant breeding, agronomy, horticulture, plant pathology
Animal management	Breeding, production, and use of domestic animals, their diseases and pests	Animal husbandry, animal breeding, animal industry, veterinary science
Soil management	Treatment and use of soil for agricultural purposes, soil conservation	Irrigation, fertilization, soil composition, soil conservation
Technology	Application and development of scientific knowledge for practical usage	Food technology, wood technology, bioengineering, synthesis of organic chemicals
Methodology	Development of new techniques for use in life sciences	All disciplines
Equipment design	Development of new equipment for use in life sciences	All disciplines

Table 2. (*Continued*)

Category	Definition	Examples of pertinent disciplines
Training	Imparting special skills for serving the life sciences, but not fellowships or scholarships	All disciplines
Scientific information	Aids to the communication process in life sciences; surveys, publications, lectures, conferences, seminars, symposia, reviews, international travel, and so forth	All disciplines
Facilities	Development or maintenance of stations, laboratories, committees, trust funds, and so forth, dedicated to research endeavor, but not construction grants	All disciplines

is familiar with the expense of human experimentation.

The applied agricultural categories—plant, animal, and soil management—ranked lowest in funds per project. It should be remembered that these figures represent the *federal contribution* to research endeavors carried out in nonfederal institutions and supported in part by the recipient institution. The apparent low cost of the projects in the agricultural categories is largely the result of the fact that this support, which comes almost entirely from the Office of Experiment Stations (OES) of the Department of Agriculture, consists mostly of grants to state experiment stations which traditionally have been administered on a cost-sharing basis. It is estimated that in fiscal 1954 state support to experiment stations was about 5 times as great as the federal commitment.

Commitments to basic research. Taking the data of Table 3 at their face value, one can estimate the proportion of federal funds for grants and contracts in the life sciences committed to basic research. The estimated support for the seven basic categories amounted to about $26 million, which was about 40 percent of the total. It would be unwise, however, to interpret this figure too literally because of the previously mentioned difficulty of distinguishing basic from applied research.

Agency support to categories. Table 4 shows the distribution of agency funds among categories. It is clear that the research interests of the federal agencies differ widely. The Department of Agriculture supported research principally in agriculture and food technology. The interest of the Atomic Energy Commission in all aspects of the biological effects of irradiation resulted in a widespread distribution of its funds with special emphasis, however, on the molecular, genetic, and pathological effects. The Army Chemical Corps (ACC) and the Surgeon General's Office (SGO) heavily supported research in the medical sciences and in basic physiology (regulatory biology). The Army Quartermaster Corps (OQMG) was principally concerned with food technology. The Navy supported research in all fields except agriculture, but with the main emphasis on molecular and regulatory biology. The interest of the Air Force in low pressure physiology was reflected in its heavy support of regulatory biology. The Department of Health, Education, and Welfare gave substantial aid to nearly all fields except agriculture, but, as with the Army Chemical Corps and the Surgeon General's Office, its main interests were in the medical sciences and in regulatory biology. The interest of the Fish and Wildlife Service (F&W) and the Bureau of Reclamation (BuR) of the Department of the Interior in wildlife and soil conservation was shown by support of environmental biology and soil management. The National Science Foundation concentrated its efforts in the basic disciplines and in interdisciplinary categories. The Tennessee Valley Authority supported agricultural research, and the Veterans Administration supported principally medical research.

If one considers the data from the point of view of the proportion of category funds provided by each agency, it is clear that the major support for nearly all categories except for the agricultural sciences came from the Department of Health, Education, and Welfare. This pattern is largely a consequence of this department's great over-all size relative to the other agencies. However, the National Science Foundation led in the support of the categories of systematic biology and scientific information, and the Army Quartermaster Corps led in technology. In the applied agricultural sciences, the sole federal support of any consequence came from the Department of Agriculture.

Recipients

In order to obtain information concerning the distribution of federal support

Table 3. Distribution by category of federal grants and contracts for unclassified research in the life sciences for fiscal year 1954.

Category	No. of projects	Annual rate (thousands of dollars)	Average annual rate per project (thousands of dollars)	Percentage of total funds
Molecular biology	833	7,485.0	8.986	11.6
Regulatory biology	1310	12,460.6	9.512	19.3
Structural biology	123	1,027.6	8.354	1.6
Genetic biology	191	1,577.4	8.259	2.4
Developmental biology	232	1,694.0	7.302	2.6
Environmental biology	170	1,601.6	9.421	2.5
Systematic biology	78	445.6	5.713	0.7
Pathology	1000	12,238.7	12.239	19.0
Diagnosis	93	860.5	9.253	1.3
Therapy	473	6,539.6	13.826	10.1
Community health	290	4,082.7	14.078	6.3
Plant management	1454	4,114.0	2.829	6.4
Animal management	752	2,989.8	3.976	4.6
Soil management	285	1,022.7	3.588	1.6
Technology	482	3,113.5	6.459	4.8
Methodology	60	431.9	7.198	0.7
Equipment design	75	656.1	8.748	1.0
Training	12	74.3	6.192	0.1
Scientific information	87	676.4	7.775	1.0
Facilities	144	1,440.9	10.006	2.2
Total	8144	64,532.9	7.924	99.8

Table 4. Distribution by agency and category of federal grant and contract funds for unclassified research in the life sciences for fiscal year 1954. Amounts are in thousands of dollars.

Category	USDA		AEC	DOD					DHEW	USDI		NSF	TVA	VA	Total
				USA			USN	USAF							
	OES	ARS		ACC	SGO	OQMG				F&W	BuR				
Molecular biology	71.0	21.0	1416.2	64.9	369.7	111.1	639.7	26.9	4,345.1			380.7		38.7	7,485.0
Regulatory biology	287.5	17.8	824.2	195.9	1156.5	86.7	1000.7	1071.3	7,521.7	2.7		290.2		5.4	12,460.6
Structural biology	4.2		40.2		48.1	15.1	50.0	137.1	709.3			23.6			1,027.6
Genetic biology	93.2		597.3		50.9		70.8		647.8			117.4			1,577.4
Developmental biology	42.8		98.6		25.6		79.2		1,376.3			71.5			1,694.0
Environmental biology	34.3		154.4	28.6	143.8	297.4	291.6	130.6	375.2	47.7		98.0			1,601.6
Systematic biology	13.1				5.7		29.7	31.4	92.6			273.1			445.6
Pathology	8.5		2148.8	76.2	1361.8	17.1	369.6	464.7	7,724.6					67.4	12,238.7
Diagnosis			54.3		122.8		44.2	1.7	625.0					12.5	860.5
Therapy	15.1		443.4	108.6	1207.9	36.0	147.3	92.2	4,460.2					28.9	6,539.6
Community health	352.3		276.3	203.5	1236.9	165.7	119.4	144.1	1,572.1				12.4		4,082.7
Plant management	4,018.5		28.7				23.0		2.8		4.0		37.0		4,114.0
Animal management	2,820.8	40.1	24.9	9.1					92.6				2.3		2,989.8
Soil management	861.3		7.1						2.3		17.4		134.6		1,022.7
Technology	1,053.5	281.7	31.2	9.9	358.9	769.2	53.4	116.3	439.4						3,113.5
Methodology	30.4				4.3	71.3	22.8	15.6	287.5						431.9
Equipment design	82.9		13.5		140.9	36.5	68.1	28.2	223.6	51.0		11.4			656.1
Training					3.8		6.3		46.9			17.3			74.3
Scientific information	37.8		20.0		46.7	23.8	65.3	111.2	181.7			189.9			676.4
Facilities	380.1		4.4		217.9		245.3		523.0			70.2			1,440.9
Total	10,207.3	360.6	6183.5	696.7	6502.2	1629.9	3326.4	2371.3	31,249.7	101.4	21.4	1543.3	186.3	152.9	64,532.9

to various types of institutions, the recipients were grouped according to the following seven classes: (i) academic institutions; (ii) nonprofit research institutes—museums, foundations, botanical gardens, biological stations, libraries, and associations actively involved in research; (iii) hospitals, clinics, and so forth—hospitals, clinics, departments of health and sanitation, and sanitaria; (iv) nonprofit associations—academies, societies, foundations, commissions, committees, clubs, journals, and congresses not actively engaged in research; (v) federal agencies; (vi) industrial organizations—commercial research institutes and industrial associations; and (vii) individuals.

The distinction between "academic institutions," "nonprofit research institutes," and "hospitals, clinics, and so forth" was not always clear. We followed the procedure of classifying hospitals or research institutes as "academic institutions" if they were administratively responsible to an academic institution.

Table 5 shows the distribution of federal grants and contracts by class of recipient. By far the largest share of support for the life sciences went to academic institutions. However, the rate of support per project was lowest for academic institutions. This is in part the result of the inclusion in this group of the relatively small grants of the Office of Experiment Stations. If these are eliminated from consideration, the average rate for academic institutions was about $10,000, which is still lower than the average of the other groups except for grants to individuals. This figure is partly a reflection of the small size of the research projects; it is probably also a reflection of the fact that a larger share of the cost is borne by the academic institution as part of its traditional sympathy for, and support of, research.

Industrial organizations received only a small fraction of federal funds for research in the life sciences. This support was largely accounted for by funds from the Army Quartermaster Corps and the Agricultural Research Service (ARS) of the Department of Agriculture for support of research in food technology. Federal institutions also received a very small fraction of life-science research funds. Whatever support existed was largely accounted for by grants to the Smithsonian Institution for support of the Bio-Sciences Information Exchange and to the Library of Congress for special services. It included also a few grants for support of the research programs of federally employed scientists. One finds that the federal agencies made very few grants to individuals. This pattern is for the most part due to a considered policy of federal agencies, but would be largely true in any case, since modern scientists are usually affiliated with academic or research institutions that provide the elaborate facilities needed for the accomplishment of research.

Since the bulk of these federal funds are distributed to academic institutions, and since the effect of these funds on the recipient educational institutions is a matter of national concern, it seems important to estimate the magnitude of federal support to academic institutions relative to support from other outside sources. Preliminary figures collected by the National Science Foundation in a study of financial support of research in colleges and universities indicate that, in the fiscal year 1954, academic institutions received between $20 million and $30 million from industry, private foundations, fund raising organizations, and other nongovernment sources. Thus the federal support of $53 million probably represents no less than 64 and no more than 72 percent of the total external contribution to educational institutions for research in the life sciences. Whether

Table 5. Distribution by class of institution of federal grants and contracts for unclassified research in the life sciences for the fiscal year 1954.

Class of institution	No. of projects	Annual rate (thousands of dollars)	Average annual rate per project (thousands of dollars)
Academic institutions	7277	53,131.5	7.301
Nonprofit research institutes	250	3,433.3	13.733
Hospitals, clinics, and so forth	444	5,430.7	12.231
Nonprofit associations	83	1,078.0	12.988
Federal agencies	22	349.0	15.864
Industrial organizations	52	957.9	18.421
Individuals	16	152.5	9.531
Total	8144	64,532.9	7.924

one uses the smaller or the larger estimates for the contribution of nongovernment sources, federal influence on the life sciences in academic institutions through grant and contract policies may be expected to be relatively significant compared with the effect of policies of the other off-campus groups.

Total Federal Support to Science

Although the grant and contract funds reported in this paper constitute a major segment of the total funds for grant and contract research in the life sciences, they represent but a very small part of the over-all federal expenditure for research and development. For fiscal year 1954, the total federal obligations in the physical, life, and social sciences amounted to $1762 million (*6*). Of this, 87 percent was for the physical sciences, 2 percent for the social sciences, and the remaining 11 percent, or $195 million, for the life sciences. Thus, the sum of approximately $64.5 million expended for unclassified grants and contracts in fiscal year 1954 amounted to about one-third of the total federal obligation for the life sciences and about 3.7 percent of the over-all federal financial commitment for all research and development.

References and Notes

1. *Federal Grants and Contracts for Unclassified Research in the Life Sciences, Fiscal Year 1954* (National Science Foundation, Washington, D.C., 1955).
2. The data presented in this article are from official findings of the National Science Foundation. However, the conclusions whether stated or implied are those of the authors and do not necessarily reflect the views of the National Science Foundation.
3. *Federal Grants and Contracts for Unclassified Research in the Life Sciences, Fiscal Year 1952* (National Science Foundation, Washington, D.C., 1954).
4. S. L. Deignan and E. Miller, *Science* 115, 321 (1952); 119, 661 (1954).
5. A. T. Waterman, *Public Health Repts.* 69, 378 (1954).
6. *Federal Funds for Science IV. The Federal Research and Development Budget.* Fiscal years 1954, 1955, and 1956. (National Science Foundation, Washington, D.C., 1955.)

C. M. Louttit, Psychologist

The death of Chauncey McKinley Louttit on 24 May 1956 was a great loss to psychology and to the behavioral sciences. Louttit will be missed as one of psychology's more versatile and productive contributors and as the very able editor of *Psychological Abstracts.* After a brief, known illness, Louttit succumbed to leukemia. He is survived by his wife, Laura, née Talcott, two sons, Robert I. and Richard T., and a brother, Henry I. Louttit.

Louttit was born 9 October 1901 in Buffalo, New York. Following a battle in his teens with tuberculosis and subsequent work as a miner in the Southwest and as an assistant in a color physics laboratory, he spent a year in the College of Forestry at Syracuse University and then transferred to Hobart College, where he received the A.B. degree in 1925. He became a research assistant at the Training School, Vineland, New Jersey, and a graduate student at Yale University, which awarded him a Ph.D. degree in 1928. In the same year, his *Bibliography of Bibliographies on Psychology, 1900–1927* was published by the National Research Council.

Following completion of his studies at Yale, his first appointment was as research psychologist in the psychological clinic of the University of Hawaii, where for 2 years he was associated with Stanley D. Porteus in studying culture-free behavior. After a year at Ohio University as assistant professor of psychology, he went to Indiana University in 1931 as director of the psychological clinics and assistant professor of psychology, where he developed one of the earlier and better-known programs of graduate training in clinical psychology. In 1933, his *Handbook of Psychological Literature* appeared, and, in 1936, his *Clinical Psychology; A Handbook of Children's Behavior Problems.* Both of these handbooks were "firsts" in psychology. The latter was especially influential in developing the field of clinical psychology and was a significant stimulus in the field of child development.

Despite a heavy schedule of teaching, writing, and research at Indiana University, he concerned himself with psychological problems in various institutional and community settings throughout Indiana and was a very active participant in the American Association for Applied Psychology, in which he served as executive secretary (1940–42) and as president (1943). Yet, with these and many other professional and scientific concerns, he was always available to his students, who found in him an unfailing source of stimulation and encouragement.

His services during World War II were substantial and extended to many important activities. Commissioned a lieutenant commander in 1940, he was assigned to duty with the U.S. Naval Medical School, in which he served as a consultant in the development of the initial plans for the psychological aspects of psychiatric screening of recruits at naval training stations. He then became chief of the clinical psychology section, and subsequently assistant chief of the psychological division, research and analysis branch, of the Office of Coordinator of Information. He next served as coordinator and executive officer in charge of quality control for naval training schools, which led to subsequent assignments as commanding officer of the Naval Training School at Plattsburg, New York, and the Naval Training Center at Bainbridge, Maryland. He retired from active duty in the navy with the rank of captain in the latter part of 1945.

Following the war Louttit became professor of psychology and director of the psychological clinic at Ohio State University, where a community-oriented behavior clinic was established and a graduate training program in clinical psychology was developed in cooperation with the Veterans Administration. Then, beginning in the latter part of 1946, Louttit yielded to a growing interest in the field of college administration and accepted several appointments in this field during the next several years. He was, in turn, dean of the faculty at Samson College, executive dean of the Galesburg Division of the University of Illinois and assistant to the provost at the University of Illinois before he accepted his last position as professor of psychology and chairman of the department of psychology at Wayne University in 1954.

At Wayne University, Louttit, with typical enthusiasm, initiative, and a prophetic sense of values, was working toward a broadly conceived graduate training program in psychology which his friends feel will be a significant advance in graduate education.

Throughout his career, Louttit showed a keen sense of responsibility to his profession and to science in general. It was typical of him that he accepted so willingly the unsalaried editorship of *Psychological Abstracts* and spent his energies so freely in further expanding and developing this important resource in the behavioral sciences. He was never so occupied that he neglected his editorial and other such duties; his responsibilities as a consultant in psychology to the National Institute of Mental Health, the Library of Congress, and other such organizations; or colleagues and students who requested counsel and advice on scientific, professional, or personal problems.

He was curious about many things. He had the energy and the courage to pursue wherever his curiosity led and also the ability and creativeness to be productive in whatever situation he found himself. Above all, he had a capacity for enjoying his work which was the envy of those who knew him.

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H. B. Williams, Physician and Physiologist

Horatio Burt Williams, emeritus professor of physiology, College of Physicians and Surgeons, Columbia University, died at Harkness Pavilion on 1 November 1955 at the age of 78 years.

Born in Utica, New York, 17 September 1877, the son of Horatio Olin and Julia Pierce Williams, he spent his early life in northern New York State where he attended Syracuse University, receiving an A.B. degree in 1900 and the M.D. degree 5 years later.

In 1905 Dr. Williams moved to New York City and in that year married Abbie Prentiss Schermerhorn. The Schermerhorn name is prominent in both the early history of New York and of Columbia University. Mrs. Williams died in 1944.

Dr. Williams interned at New York Hospital in 1905–06, after which he practiced medicine and acted as assistant in physiology at Cornell University Medical School (1907–11). He was called to Columbia University in the spring of 1911 as associate professor of physiology and, with the exception of his Army service in World War I, served continuously in that department until he retired as Dalton professor of physiology in 1942.

Dr. William's name is associated with the early history and development of electrocardiography in the United States. His paper, written with Walter B. James, "The electrocardiogram in clinical medicine," which appeared in 1910 in the *American Journal of Medical Sciences*, is, we believe, the first publication on electrocardiography in this country.

Williams spent most of the summer of 1911 in the laboratory of William Einthoven in Leyden. On his return he duplicated the Einthoven string galvanometer. This apparatus was costly, complicated to operate, and completely filled a moderate-sized room. In 1914, Williams designed and supervised the construction of the first American Einthoven string galvanometer for the use of Alfred Cohn at the Rockefeller Institute for Medical Research. This instrument is now on permanent exhibition in the Smithsonian Institution in Washington, D.C. Williams' intensive theoretical and experimental study of the Einthoven string galvanometer resulted in successive reductions in size and weight of the electrocardiograph. He was one of the founders of, and a director and technical adviser to, the Cambridge Instrument Company, Inc., from 1922 until the time of his death.

Perhaps the most interesting investigation carried out by Dr. Williams and his associates was on the effect of electric shock on the heart. This showed that fibrillation produced in the hearts of experimental animals by the passage of an electric current could be abolished in most instances by an electric countershock of high intensity and short duration. Williams' interest in this field led to his appointment as chairman of the Resuscitation Review Board of the Edison Electric Institute. He served also as a member of the Committee on Safety of the American Institute of Electrical Engineers (1943–44 and 1945–51).

Although a doctor of medicine, Dr. Williams held a captain's commission in the U.S. Army Corps of Engineers. During World War I, he was an instructor in the Army Engineers School at Fort Belvoir. Many of the graduates of this school later attained positions of high rank. Professor Williams was concerned also with the development and construction of sound-ranging instruments used for locating enemy guns.

Dr. Williams was an outdoor sportsman. For several years he was camp director of a boy's camp in the Adirondack Mountains. He was an expert rifle and pistol marksman and held many cups for marksmanship. This interest led him to acquire an extensive collection of early American firearms. Early in life Williams became an enthusiastic yachtsman; later he became a skilled horseman and took great pride in his thoroughbred Thunderclap, a former race horse. Professor Williams spent most of his summers at his home Whispering Woods in Woodstock, N.Y., where he enjoyed his association with the art colony.

Williams' wide range of interests is shown by the many organizations and societies of which he was a member and by the titles of the volumes in his extensive library. In this, classical volumes mingled with scientific monographs. Although he read most of the modern foreign languages as well as Greek and Latin, he perhaps took greater pride in his ability to speak the dialects of several northern New York Indian tribes.

Williams received a number of honors. He was awarded an Sc.D. degree by Syracuse University in 1925 and delivered the fourth Josiah Willard Gibbs lecture before a joint session of the American Mathematical Society and the American Association for the Advancement of Science in 1926. He was made an honorary member of the American Society of Anesthetists. In October 1953, he received a gold medal for distinguished service at the celebration commemorating the 25th anniversary of the opening of the Columbia Presbyterian Medical Center.

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News of Science

Soviet Physiology

Following the International Physiology Congress in Brussels, Belgium, 30 July–4 Aug., four physiologists from the United States visited major physiological laboratories in Leningrad and Moscow. In the group were W. O. Fenn of the University of Rochester, C. F. Schmidt of the University of Pennsylvania, and F. A. Hitchcock and I of Ohio State University. We were received with cordial hospitality; we were given details on current physiological developments related to teaching and research; we were shown many phases of current experimental programs; and we were assured of cooperation in the exchange of publications and material for abstract notice. We enjoyed freedom of movement and photography, both in the cities and in rural areas, although it was found wise to use the helpful facilities of the Intourist Service Bureau for travel and interview arrangements. Interpreters were furnished, but we noted that most of the Russian scientists converse effectively in English, French, or German.

Soviet physiology is broadly approached but narrowly programmed. In the U.S.S.R. the discipline comprises the study of the way living things work from cells to societies, from microorganisms to man, and is medically oriented. It includes biophysics, biochemistry, cellular and comparative physiology, embryology, pathology, pharmacology, neurology, and psychology. However, it seems generally to be channeled into detailed extension of the Pavlovian canon. Plant physiology is oriented toward agriculture.

The organization of physiological teaching and research in the Soviet Union is complex. For medical students the subject is taught in the 80-some medical schools, which are independent of the universities. For those who wish to compete for a scientific position in physiology, training is available in the several physiology institutes or in the physiology laboratories of the Faculty of Biology at the University of Moscow. Thus in that institution's great new Biology Building there is the well-equipped and busy Laboratory of Animal and Human Physiology under dynamic Ch. Kostojanc, where studies are in progress on enzymo-chemical processes in nerve excitation and inhibition, and the Laboratory of Comparative Physiology of the Higher Nervous System under L. G. Voronin, where work is proceeding on the phylogenesis of "the analytico-synthetic activity" of the nervous system. At least half of the medical and graduate students are women.

The research institutes of physiology are maintained either by the Academy of Sciences or by the Academy of Medical Sciences. The latter is advisory to the Ministry of Health on drug evaluation, disease control, health promotion, and medical education and practice. Membership is by academy election for a 5-year term, with reelection on continued merit.

In Leningrad, the Academy of Medical Sciences operates the Institute for Experimental Medicine, where I. P. Pavlov (1849–1936) did most of his extraordinary work on reflex action. In Moscow it controls the Institute of Normal and Pathological Physiology, where V. N. Chernigovsky studies cortical representation of internal organs; the Brain Institute, where S. Sarkisov and his associates are examining interrelationships of structure and function in the cerebrum; and the Institute of Pharmacology and Chemotherapy, where V. V. Sakusov investigates cardiac glucosides in experimental myocarditis.

The Institute of Experimental Medicine in Leningrad, which was established in 1890, has 11 sections staffed by approximately 200 scientists and some 30 graduate students. It supports laboratories for general, comparative, and pathological physiology, microbiology, pharmacology, radiobiology, morphology and embryology, biochemistry, and biophysics. It is well equipped and has extensive grounds and buildings, including dormitories. In addition, there is a fine pedimented bronze tribute to the experimental dogs that are so carefully tended. It is at this institute that Pavlov's famous "isolation towers" are maintained for study of conditioned reflexes, and there is also a remarkable museum of his contributions and memorabilia.

At the Leningrad Institute for Experimental Medicine, the following studies are in progress: motor mechanisms in conditioned reflexes, under the director, P. S. Kupalov; the action of gangliolytic drugs on tissue metabolism, under S. V. Anichkov; the evolution of conditioned and unconditioned inhibition, under D. A. Birioukov; and the effects of temperature changes on nerve excitability in cold- and warm-blooded animals, under D. A. Nasonov. Findings were reported at the Brussels congress.

The Pavlov Institute of Physiology in Leningrad was established in 1950 under the auspices of the Academy of Sciences of the U.S.S.R. It is directed by Academician K. M. Bykov, and it includes a large laboratory building in the city as well as a well-arranged laboratory unit in the country at Kulteschi (Pavlov Village) that was designed by Pavlov and has dormitories and commodious animal quarters. The whole Pavlov Institute comprises 28 nicely equipped sections, with some 200 scientists and 700 technicians. There are two fair libraries. The purpose of the institute is to explore all aspects of Pavlov's teaching, with special reference to conditioned reflexes and corticovisceral functional interrelationships. Some of the recently reported studies from the Pavlov laboratories include cortical regulation of glandular secretion (under Bykov), cortical dynamic localization (under E. S. Airapetyants), tissue adaptation to chronic hypoxia (under E. M. Kreps), corticovisceral pathological factors in conditioned reflexes involving salivation (under F. P. Maiorova), reflex mechanisms involving gaseous exchange in the body (under A. D. Slonim), and neurological factors in silkworm reflexes (under E. Vladimirova).

A recent notable development in Soviet science is the establishment of an Institute of Evolutionary Physiology in Leningrad, which operates under the auspices of the Academy of Sciences and is directed by Leon A. Orbeli, well known for his contributions to cardiovascular physiology. A new building is under construction for this institute, which has been organized to search for physiological factors in the evolutionary process. Orbeli has many pupils working with him and has just issued the first of a series of volumes of his contributions with them. A new periodical devoted to evolutionary physiology is planned. Also, it is at this institute that A. G. Ginetsinsky is studying the influence of efferent nerves on kidney function in relation to phylogenetic factors.

In Moscow there is the Sechenov Physiology Institute, named in honor of Ivan M. Sechenov (1829–1905), the founder of Russian physiology and the man who set its course in describing cerebral inhibition of spinal reflexes. This institute is located in one of the many large buildings of the old part of the University of Moscow, across the Riding Academy Square from the Kremlin, where

Sechenov himself worked. It is under the direction of P. K. Anokhin, who, with 29 scientific associates, is studying "anticipatory reflexes" and "systemogenesis." Here there is also work on the role of the reticular formation of the brain stem in the transmission of unconditioned excitation to the cerebral cortex. The laboratories have excellent equipment and there is the usual evidence of good morale among the group.

The Academy of Sciences also supports a number of other independent physiology research laboratories in Moscow. Thus E. A. Asratyan has a special laboratory for studying the effects of extirpation of the cerebral cortex on vegetative and somatic functions. At the Institute of Biophysics, G. M. Frank, L. P. Kayushin, and R. G. Ludkovska are investigating the change in structure and mechanical properties of nerves during the spread of excitation. At the Institute of Higher Nervous Activity, V. S. Rusinov is conducting electrophysiological research on dominant areas of the higher nervous system. There is much work with elaborate electroencephalographic equipment. The conventional microscopic equipment that we saw was of high quality, and all of it was manufactured in the Soviet Union.

The Ukrainian Academy of Sciences maintains an extensive Biochemical Institute under A. V. Palladine. Here studies are in progress on the chemical and metabolic aspects of various functional portions of the brain, on brain metabolism during ontogenesis, and on brain metabolism during excitation, inhibition, and hypoxia. At the Institute of Animal Physiology of Kiev State University, P. G. Kostyuk is making intracellular recordings of end-plate potentials in repeated nerve stimulation. At the Physiology Laboratory of Rostov State University, A. B. Kogan is studying the interrelationships of conditioned reflexes, motor activity, brain potentials, and excitability of cortical neurons in chronic experiments on free behavior in normal animals. The Georgia Academy of Sciences maintains an Institute of Physiology at Tbilisi, under A. I. Roitbak, who is working on bioelectric phenomena in the cerebral cortex produced by various methods of stimulation.

Soviet physiologists are keen workers and thinkers, however closely they may be oriented toward the Pavlovian canon. They and their pupils have ready access to the world's major physiological publications. There is a comprehensive annual indexing program for biological literature, which is the basis for documentation in ordinary periodical publication. For a time during World War II many of the biological contributions from the U.S.S.R. appeared in English. The country's biological periodicals cover the conventional range. In general scientific literature, Soviet scientists seem partial to *Nature, Science,* and *Experientia.* Most of the physiology workers have small private libraries.

It is interesting that Soviet experimental work in the biological fields has little statistical control. In physical experimentation, on the other hand, it is as conventionally used as anywhere. However, animals are handled with extreme care and solicitude. Since most of the physiological work is repeated experimentation with the same animals, they tend to become pets of the workers. Thus with relative uniformity of experimental material there may not be the variation that necessitates statistical control. But philosophic factors may also be involved.

Soviet physiologists are capable and efficient in their technical work. They are generous in their personal relations, and they seem to be anxious to have their efforts known and appreciated. They would welcome the chance for correspondence and personal contact with American and other Western physiologists.

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Mathematics Teaching Essay Contest

Kappa Mu Epsilon, national honorary mathematics society, and the AAAS Science Teaching Improvement Program are cooperating in the sponsorship of an essay contest on "Opportunities in teaching mathematics in secondary schools." Satisfactory essays will be published in *The Pentagon,* official publication of Kappa Mu Epsilon. First prize in the contest will be $50. There will be second and third prizes of $25 and $15, respectively.

The Mathematics Teaching Essay Contest is planned to increase interest in the teaching of mathematics at the secondary-school level by encouraging undergraduate students in mathematics to consider the advantages of a career in secondary-school mathematics teaching. It is hoped that the preparation, as well as the reading, of the essays may attract good students with an interest in mathematics to enter the teaching profession. The importance of the ability to express oneself in writing, particularly on the part of teachers, should also be emphasized by such an essay contest.

Essays submitted in the contest should reach Prof. Carl V. Fronabarger, Southwest Missouri State College, Springfield, Mo., *no later than 1 Apr. 1957.* They must be not more than 1000 words in length and should be typed double-spaced on a good grade of paper. Four copies should be submitted by each contestant. Undergraduate and graduate students in mathematics are eligible to enter the contest.

The content of the essay should be as specific as possible and should point out the advantages of preparation for the teaching of mathematics at the secondary-school level. The essay may consider one or more of the special facets of the profession of mathematics teaching, or it may cover the general area as completely as the length of the essay will permit. The essays will be judged on accuracy and objectivity of the data presented, the degree to which the essay appears to be convincing in the case presented for mathematics teaching, and composition and neatness.

Bacteriophages in the American Type Culture Collection

Bacteriophages have become research materials of major importance in such fields as genetics, biophysics, and biochemistry as well as microbiology. It should be of considerable interest, therefore, that the American Type Culture Collection now maintains a collection of some 150 strains of bacteriophages and their host bacteria. Included among the hosts are the following genera of bacteria: *Azotobacter, Bacillus, Corynebacterium, Escherichia, Salmonella, Shigella, Serratia, Micrococcus, Staphylococcus, Streptococcus, Mycobacterium, Pasteurella, Pseudomonas, Rhizobium, Vibrio, Xanthomonas,* and *Streptomyces.* A complete catalog of the collection is available on request (2112 M St., NW, Washington 7, D.C.). Each phage strain and its host are sold separately for $4 plus shipping costs.

The collection has been built up by generous gifts from a relatively few donors, the greatest number of strains having come from I. N. Asheshov. The curator, W. A. Clark, is very anxious to obtain additional strains and will welcome gifts from any source. Donors should send both phage and host strain to the ATCC, together with literature references to the strain, history of isolation, host range, strain designations if it has been described under various names, and any useful information about preparation and preservation of phage stocks. In the case of temperate phages, the lysogenic bacterium and the indicator host should be sent as well as the phage stock.

Much of the earlier phage literature has little meaning today, because the phage strains concerned have been lost and, in most cases, cannot be related taxonomically with any strains now available. Until a usable phage taxonomy can be developed, it is essential that all phage strains that have been the subject of pub-

lished experiments be preserved. It is not the purpose of the ATCC to collect mutant strains of well-known phages, but it is interested in obtaining independently isolated strains that are taxonomically related to well-known strains. It is the hope of the ATCC that, whenever a phage strain is described for the first time, it and its host bacterium will be forwarded as type specimens to the collection.

If anyone happens to have in his possession examples of classical phage strains that are not already included in the collection (please consult the 1956 ATCC catalog of phages), they should be deposited with the ATCC. The curator is particularly anxious to obtain specimen's of Burnet's serological types of enteric phages. These strains are usually designated by numbers preceded by S, C, or D, as C16, S13, D44. Also phages for bacterial genera not at present represented in the collection are desired.

It is to be expected that as the number and variety of available phage strains increase, the value of the collection to research workers throughout the world will increase in proportion. The collection already contains a wealth of biological material that has not been examined by modern techniques.—M. H. A.

Small Animals in the Classroom

Dietrich C. Smith reports [*Bull. for Med. Research* **10**, 2 (May–June 1956)] that the use of small animals in the classroom has proved to be an unexpectedly helpful tool in teaching. The Maryland Society for Medical Research launched its "Small Animal Classroom Project" in the fall of 1954. This has since turned out to be the most popular feature in its educational program.

Projects are of two types. In the first, which is designed primarily for elementary grades, a rabbit, guinea pig, or white rat is supplied as a classroom pet; no controlled experimentation is attempted, the teaching being limited to demonstration of the proper principles of animal care combined with frequent weighings and the plotting of a growth curve. In the second and more ambitious project, designed for junior and senior high schools, a matched pair of animals, usually small male white rats, is used for a simple nutritional experiment that illustrates retardation of growth.

The program caught on rapidly, and at the time that Smith wrote his article more than 150 projects had been placed in all parts of the state. In addition to supplying animals and detailed instructions for their maintenance, including directions for building a cage, the society provides an adequate and a vitamin-deficient diet schedule and directions for carrying out the nutritional experiment.

The program has been very successful, and in many cases the educational use of the animals has been extended by the ingenuity of individual teachers. The projects have been especially helpful in bringing into sharp focus the role of animals in the advancement of knowledge. —W.L.S., Jr.

U.S.-Brazilian Uranium Agreements

Brazil has suspended the export to the United States of minerals used for nuclear energy. She has also denounced the Brazilian-United States agreement for joint uranium prospecting in her territory.

United States purchases of Brazilian thorium have been relatively small and for this year were to total 300 tons of thorium oxides. There is no official record of uranium sales by Brazil, which has no commercial production, and the country's reserves still are unknown.

Although the shift in Brazilian policy is unlikely to have any important effect on the United States research program, the action is a blow to U.S. prestige in Brazil. In denouncing the prospecting and export agreements, the Brazilian Government did not, however, abrogate another pact, that under which she joined the atoms-for-peace program. As a result of this agreement, the United States is providing $350,000 toward the cost of an experimental atomic reactor for São Paulo University, lending Brazil 13.2 pounds of uranium fuel for the reactor, and making technical information available. Assistance in erecting an industrial reactor also is being negotiated.

NSF Aids Dissemination of Federal Research Results

Federally supported basic scientific research of an unclassified nature will henceforth be made more widely available to scientists everywhere under terms of a new program that has been announced by the National Science Foundation. With support from the foundation's Office of Scientific Information, the Library of Congress and the Office of Technical Services of the Department of Commerce will jointly undertake wider dissemination of significant information in the some 20,000 unclassified technical reports on basic research issued annually by organizations engaged in Government-sponsored scientific research.

Specifically, the program, designated Government Research Information, is designed to assist any research scientist (i) to learn what unclassified scientific reports on Government research are being issued in his field of interest and how he can obtain them; (ii) to obtain, on a subscription basis, a report-announcement service that automatically will keep him informed regarding the bulk of such reports in fundamental research and through which he can purchase copies of listed reports; and (iii) to obtain access to a well-cataloged reference collection of unclassified scientific reports on federally supported basic research that he can consult much as he now consults books in a reference library.

The first of the three services is offered by the Government Research Information Clearinghouse in the NSF Office of Scientific Information. The staff of the clearinghouse is experienced in technical report reference work and will assist scientists with any problems related to the existence, whereabouts, and availability of unclassified reports on Government-sponsored basic scientific research. The clearinghouse will be able to tell scientists where and how to obtain scientific reports about Government research. Mail, telephone, or personal requests should be submitted to the Government Research Information Clearinghouse, National Science Foundation, Washington 25, D.C., attention of Dwight E. Gray.

The automatic announcement service covering reports on Government-supported scientific research is an expansion of an activity that the Office of Technical Services has been offering for several years. OTS publishes the subscription journal, *U.S. Government Research Reports*, an annotated, monthly listing of reports on federally supported research. Each entry in the journal includes information on how that document can be obtained. The NSF supplemental support will permit OTS to increase its acquisitions program appreciably, insuring comprehensive coverage of reports in basic scientific research. Complete information on this announcement service and allied OTS activities can be obtained from the Office of Technical Services, Department of Commerce, Washington 25, D.C., attention of John C. Green, Director, or from the NSF Clearinghouse.

The third service—access to an unclassified report reference collection and catalog—is being offered by the Library of Congress in its Science Division. With NSF supplemental support, the library has consolidated and augmented its scientific report holdings and has established open-card and book catalogs covering these substantial report collections. Readers are free to consult the report catalog, and reference assistants will bring them copies of any reports they wish to see. As in the case of the library's book collections, reports cannot be taken out. In general, however, any report in this open collection can be purchased, either from OTS or, in photoreproduced

form, from the library itself. Complete information on the scope and functioning of this report reference service can be obtained from the Science Division, Library of Congress, Washington 25, D.C., attention of John Sherrod, Acting Chief, or from the NSF Clearinghouse.

Salaries for Chemists

Salaries for chemists just out of college have risen more than 23 percent in the past 4 years, according to a nation-wide survey conducted by the American Chemical Society. For the same period, the U.S. Department of Labor figures indicate a rise in the cost of living of about 3 percent. The median starting pay for chemists who were graduated last June with the bachelor's degree is $400 a month, as compared with $325 in 1952.

For beginning chemical engineers with the bachelor's degree, the median figure has climbed from $343 in 1952 to $425 this year, a gain of 23.9 percent. Graduates with the master's and doctor's degrees have enjoyed similar percentage gains. The survey report, which appeared in the 3 Sept. issue of *Chemical and Engineering News,* was prepared by B. R. Stanerson, of Washington, D.C., assistant secretary of the ACS. ACS surveys conducted since 1952 have shown a steady increase of 3 to 8 percent a year in starting salaries for chemists and chemical engineers.

Mauna Loa Observatory

A high-altitude observatory on the slope of the Hawaiian volcano, Mauna Loa, was dedicated this summer. It is being operated jointly by the National Bureau of Standards and the U.S. Weather Bureau. Located at a height of 11,134 feet in the tropics, where the upper atmosphere is very clear and usually of low moisture content, the new observatory offers special advantages for many types of astronomical and upper-air studies. It will make possible continuous observation of atmospheric phenomena with manned instruments rather than with the unmanned meteorological balloons that have been used to such a great extent in high-altitude work.

Among the advantages of the Mauna Loa observatory are its ready accessibility and relatively warm climate. Most of the other comparable observatory sites are buried in snow during winter and part of the summer. Also, the Mauna Loa observatory has the required altitude without the ruggedness that imparts turbulence to the surrounding air, and it is situated at a key point for studying the huge air masses of the tropics.

The chief research results to be expected from the observatory are improved long-range weather forecasting and greater knowledge of solar and atmospheric radiation. Because the air masses of the Pacific are responsible for much of the weather that occurs in other parts of the world, data on these air masses may make it possible to forecast conditions in distant places.

There is some evidence that the ozone content of the lower atmosphere in the tropics is associated with the formation of the large low-pressure areas that produce typhoons. Continuous measurement of atmospheric ozone may thus be of assistance in forecasting typhoons in advance.

The observatory also offers possibilities for study of cosmic rays, total solar radiation, snow crystals, air glows, and possibly radioactive fallout. In July, C. C. Kiess and C. H. Corliss of NBS began a study of the moisture content of the planet Mars under the auspices of the National Geographic Society. They used spectroscopic techniques to investigate the light reflected to the earth from Mars. The advantageous location of the Mauna Loa observatory made it possible to reduce the effect of the earth's atmosphere on the planet's spectrum.

During the coming year Ralph Stair of NBS expects to begin a study at Mauna Loa on the distribution of the spectral energy from the sun. Such information will be of value in determining the effect of the sun's rays in connection with high-altitude equipment, space flights, and man-made satellites. This work will also furnish data on the solar constant and information on solar intensities that may be useful in many fields.

The observatory is a concrete-block structure that cost $25,000; it is situated about 2500 feet below the summit of the mountain. The building contains five rooms in addition to a tower and a broad open platform for observational use. Present accommodations permit the use of the buildings by a maximum of six observers at any one time.

A smaller structure was built at the summit in 1951–52, but the limited observations that were taken there were discontinued in 1954 because of the extreme difficulty of traversing the trail to the summit. It is hoped that at some future time a functional unit can be established at the summit.

News Briefs

- A large radiotelescope was mounted near Bonn, Germany, early this month. The parabolically shaped antenna, which measures 82 feet in diameter, rests on a 52-foot-high cone-shaped cement structure.

- The Swiss Federal Solar Observatory has predicted that the highest number of sunspots hitherto recorded will be surpassed in January 1957. Observations are important because of sunspot effects on the ionosphere, the ionized layer in the sky that reflects radio waves.

- The United States has transmitted to the United Nations a report on *Radioactive Fallout through September 1955* [M. Eisenbud and J. H. Harley, *Science* **124**, 251 (10 Aug. 1956)]. This summarizes data obtained by the Atomic Energy Commission in the period 1951–55 from its network of 88 monitoring stations here and abroad. The AEC's experience in the collection and analysis of radioactive fallout, as well as the necessary apparatus, has been offered to United Nations members to assist in current world-wide investigations of the effects of radiation on human health and safety.

Scientists in the News

RICHARD G. AXT, study director for institutional research at the National Science Foundation, has been appointed assistant director of the Western Interstate Commission for Higher Education. The commission, which is supported by 11 western states and territories, has offices at the University of Colorado, Boulder.

RAYMOND C. MOORE, professor of geology at the University of Kansas, will receive the 29th Hayden memorial geological award of the Academy of Natural Sciences of Philadelphia, on 15 Nov. The award, a medal and $300 honorarium, is given every 3 years for the "best publication, exploration, discovery or research in the science of geology and paleontology, or in such particular branches thereof as may be designated."

CHARLES D. HENDLEY, formerly pharmacologist for the Wallace Laboratories division of Carter Products Incorporated, New Brunswick, N.J., has joined the pharmacology department of the Schering Corporation, Bloomfield, N.J.

H. J. EMELEUS, professor of inorganic chemistry at the University of Cambridge (England), will be the Baker lecturer in chemistry at Cornell University this fall. He will lecture on the halogens each Tuesday and Thursday from 2 Oct. to 6 Dec. Recent research by Emeleus has been chiefly on the chemistry of fluorine compounds and on the chemistry of hydrides. His earlier work was on chemical kinetics, preparative inorganic chemistry, and problems of the chemiluminescence of phosphorus, arsenic, sulfur, and organic compounds.

WARDELL B. POMEROY and PAUL H. GEBHARD have been named codirectors of the Indiana University Institute for Sex Research, where they have been long-time staff members. They will carry on the work of ALFRED C. KINSEY, founder of the institute, who died on 25 Aug.

CHARLES D. W. THORNTON, for 13 years in the U.S. Atomic Energy Commission, has been appointed director of research for Farnsworth Electronics Company, Fort Wayne, Ind.

RAYMOND A. HEISING, radio pioneer and consulting engineer, who was associated with the Western Electric Company and Bell Telephone Laboratories from 1914 until his retirement in 1953, is to receive the Founders award of the Institute of Radio Engineers for his "leadership in Institute affairs, for his contributions to the establishment of the permanent IRE Headquarters, and for originating the Professional Group system." Presentation will be made at the annual IRE banquet to be held at the Waldorf-Astoria Hotel, New York, on 20 Mar. 1957 during the institute's national convention.

JULIUS A. STRATTON, chancellor of the Massachusetts Institute of Technology, is also to be honored at the banquet. He will be presented with the IRE medal of honor, the highest technical award in the radio and electronics field, for his "inspiring leadership and outstanding contributions to the development of radio engineering as a teacher, physicist, engineer, author, and administrator."

TORBEN H. MEISLING, formerly with the Lincoln Laboratory at the Massachusetts Institute of Technology, has joined the Stanford Research Institute as a senior research engineer in the computer laboratory. Meisling, who is a native of Copenhagen, Denmark, is a specialist in systems design and was in charge of transistor procurement, testing, and circuits theory at the Lincoln Laboratory.

McKEEN CATTELL, head of the department of pharmacology at Cornell University Medical College since 1936, has been appointed to the new position of administrator of grants for the American Cancer Society. During the current fiscal year, which began on 1 Sept., the society will allocate $8 million for research.

MARSHALL N. ROSENBLUTH, a theoretical physicist at Los Alamos Scientific Laboratory, has joined the General Atomic Division of the General Dynamics Corporation, San Diego, Calif.

FERDINAND G. BRICKWEDDE, chief of the Heat and Power Division, National Bureau of Standards, has been named dean of the College of Chemistry and Physics at Pennsylvania State University. He succeeds George L. Haller, who resigned more than a year ago to become manager of the laboratories department of General Electric's Electronic Division.

During his more than 30 years with NBS, Brickwedde devoted himself to low-temperature physics and thermodynamics research and to the improvement of the standards of temperature measurements. For the past 11 years, he has been interested in the improvement of the standards of rheology and the octane rating of automotive gasolines.

R. E. HUNGATE, professor of bacteriology at the State College of Washington, has resigned to join the department of bacteriology at the University of California, Davis.

WILLIAM DAMESHEK, professor of medicine at Tufts University, School of Medicine, will deliver the first Samuel H. Golter lecture of the City of Hope Medical Center, Duarte, Calif., on 15 Nov. at the Ambassador Hotel, Los Angeles. He will discuss the current status of myeloproliferative disorders. The lecture is to be given annually by a medical research worker who deals with one of the diseases of special interest to the City of Hope Medical Center.

DONALD G. FINK, director of research for the Philco Corporation, Philadelphia, Pa., is to receive the 1956 Journal award of the Society of Motion Picture and Television Engineers on 9 Oct. during the society's 80th convention in Los Angeles, Calif. He is being honored for his paper on "Color television vs. color motion pictures," which appeared in the June 1955 issue of the society's journal.

THEODORE J. BAUER, for the past 3 years chief of the U.S. Public Health Service's Communicable Disease Center in Atlanta, Ga., has been named deputy chief of the Bureau of State Services. He replaces Leroy E. Burney, recently appointed Surgeon General of the service.

Recent Deaths

ROBERT F. ANDERSON, West Chester, Pa.; 91; professor emeritus of mathematics and former head of the department at West Chester State Teachers College; 31 Aug.

CHARLES E. BENNETT, Ridgewood, N.J.; 74; electrical engineer and inventor; 31 Aug.

ANTON J. CARLSON, Chicago, Ill.; 81; professor emeritus of physiology and former head of the department at the University of Chicago; vice president AAAS Section N in 1925; 97th president of AAAS in 1944; 2 Sept.

MOSES KESCHNER, New York, N.Y.; 80; former clinical professor of neurology at Columbia University; 31 Aug.

JOHN W. SCOTT, Laramie, Wyo.; 85; emeritus professor of zoology and former chairman of the department of zoology at the University of Wyoming; 15 Aug.

JOSEPH SHRYOCK, Wawa, Pa.; 76; civil engineer; 29 Aug.

MERRILL A. STAINBROOK, Brandon, Ia.; 59; retired professor of geology at Texas Technical College; 10 July.

GUSTAV SWOBODA, Geneva, Switzerland; 63; former chief of the Czechoslovak Weather Service; secretary general of the World Meteorological Organization from 1951 to 1955; 4 Sept.

FREDERICK D. WEIDMAN, Llanerch, Pa.; 74; emeritus professor of dermatology at the University of Pennsylvania; associate pathologist of the Zoological Society of Philadelphia; 30 Aug.

Education

■ The U.S. Atomic Energy Commission has established two new programs to assist colleges and universities to expand facilities for training in nuclear energy technology. The purpose of the plan is to increase the supply of the nuclear engineers, scientists, and technicians.

Under the first of the new programs the commission will make grants toward the cost of equipment to be used in course work dealing with nuclear energy technology. Grants made to any single institution may not total more than $350,000.

Under the second new program, source and special nuclear material will be lent without charge for use, burn-up, fabrication, preparation of fuel solutions, or reprocessing material after use. By-product materials will be furnished at a cost of 20 percent of list price. Certain other materials peculiarly related to nuclear energy technology will be furnished without charge. The value of materials lent to any single institution may not total more than $50,000. Details of the new programs, for which Congress has appropriated funds, may be obtained by writing to the Director, Division of Reactor Development, U.S. Atomic Energy Commission, Washington 25, D.C.

■ The American Medical Association reports that 28,639 students are enrolled in 76 approved 4-year medical schools and in six schools giving the first 2 years of medical training, a record high.

■ A new computer laboratory has been established on the University of California's Berkeley campus. It will begin operation in October with an IBM 701 that has been at the university's Radiation Laboratory in Livermore for the past 2 years. The budget for the laboratory's first year of operation will be $154,233.

■ The National Science Foundation has awarded a grant of $500,000 to the Massachusetts Institute of Technology in support of a reactor for nuclear research. The remaining cost of the $2-million facility will be covered by funds raised by M.I.T. alumni and by a $250,000 grant from the Rockefeller Foundation. The NSF and Rockefeller awards make it possible for the institute to proceed with the construction of the reactor, plans for which have been under way since 1952.

The reactor's medical and biological facilities will be centered in a therapy room, located underground directly beneath the reactor itself. Neutrons from the fission in the reactor will enter the room through the ceiling. This design is the key difference between the M.I.T. reactor and others now being built. The therapy room will, in effect, be a large and completely equipped operating room, making possible the irradiation of patients immediately after surgery.

■ Free college-credit courses by television, open to the general public as part of Chicago's program of public education, began on 12 Sept. The four credit courses—general biology, freshman English, social science, and national government—are being offered over WTTW by the Amundsen, Crane, Wilson, and Wright branches of the Chicago City Junior College.

Each of the four courses will be presented in 45 half-hour sessions, 3 days a week. Kinescope film of these programs will be shown to evening viewers 1 week later.

A free information folder, containing the course outlines, is available to anyone on request. Noncredit viewers may receive the study guide, including work assignments, for a charge of 50 cents.

Registration for credit is open to high-school graduates and to any adult 21 years of age or older. Legal residents of Chicago pay only the usual college general service charge. Students outside the city limits may enroll for credit, but they will be charged the usual nonresident tuition in addition to the service charge. Examinations will be held on the college campuses for credit students.

■ Lafayette College has lent a team of educators to Iran for the development there of the new Abadan College of Engineering. To prepare students for Abadan, a junior college has been formed. The first class enrolls this month and will be taught by the visiting group. The groundwork for establishment of the new college was laid by Lafayette educators and engineers who visited Iran last spring and made a survey of the Abadan Technical Institute that was established by the Anglo-Persian Oil Company in 1935. Lafayette was asked to make the survey by officials of the Iranian Oil Company and associated United States and European companies.

■ Dartmouth College and its Thayer School of Engineering have announced a new program in engineering science that will be the basis for all engineering studies at the college. It will lead to a bachelor of arts degree in 4 years. To receive a bachelor of science degree, a candidate must enroll for an additional year of study in a civil, mechanical, or electrical engineering program.

Miscellaneous

■ An exhibit built around one of the largest known shooting stars opened on 1 Sept. at the American Museum–Hayden Planetarium in New York. Ahnighito, the 34-ton meteorite which has been screened off from public view for 9 months, now rests on a large scale especially built for it by the Toledo Scale Company. Included in the new exhibit is a panel of ten photographs that tell the story of the meteorite's discovery by Adm. Robert E. Peary at Cape York, Greenland, in 1894 and of its subsequent journey to the American Museum.

Ahnighito is one of three meteorites recovered from the Cape York peninsula by Peary. It is the second largest meteorite known to exist. It is 10 feet 10 inches long, 7 feet 2 inches high, and 5 feet 6 inches thick. Still larger is the Hoba West meteorite, estimated to weigh between 50 and 60 tons, which lies partly buried in the ground where it fell near Grootfontein in South Africa.

■ The Civil Service Commission has announced an examination for geophysicist (exploration) for filling positions in the Geological Survey and various other agencies in Washington, D.C., and throughout the United States. Some positions may be filled in United States territories and possessions, and in foreign countries. The entrance salaries range from $3670 to $11,610 a year.

For positions paying $3670 and $4525, education alone may be qualifying. No written test is required. Further information and application forms may be obtained at many post offices throughout the country, or from the U.S. Civil Service Commission, Washington 25, D.C.

■ *Report of NRL Progress*, published monthly by the Naval Research Laboratory, can now be obtained on a subscription basis from the Office of Technical Services. Annual rates are $10 for a domestic subscription, and $13 for a foreign one. A single issue is $1.25. Orders should be addressed to OTS, U.S. Department of Commerce, Washington 25, D.C.

■ A competitive examination for appointment of medical officers to the regular corps of the U.S. Public Health Service will be held on 27, 28, 29, and 30 Nov. at various places throughout the United States. A candidate will be tested at the examination center nearest his home.

Gross pay is identical to that of officers of equivalent rank in the Army and Navy. Regardless of grade at which an officer is appointed, assistant or senior assistant, entrance pay will be that of the senior assistant grade; for officers with dependents, this is $7498 per year. (Assistant-grade entrants are assigned the temporary grade of senior assistant.) Entrance pay includes the $1200 annual incentive pay received by medical officers as well as subsistence and rental allowance.

Application forms may be obtained by writing to the Chief, Division of Personnel, U.S. Public Health Service, Department of Health, Education, and Welfare, Washington 25, D.C., or from field stations of the Public Health Service. Transcripts covering all undergraduate and graduate education should accompany application forms. Completed forms must be received in the Division of Personnel *no later than 13 Oct.*

■ Articles appearing in the October issue of *The Scientific Monthly* are, "Science, humanities, and artifacts," Harcourt Brown; "New interpretation of the surface of Mars," Dean B. McLaughlin; "Interindustry analysis, new tool in economics," John H. Cumberland; "Studies on deep mass culture of algae in Israel," A. M. Mayer, A. Eisenberg, M. Evenari.

The "Association Affairs" section includes the program for the new headquarters building dedication, an account of AAAS meetings held in New York between 1887 and 1956, the financial report for 1955, and items on the Science Teaching Improvement Program and the junior academies of science. Twelve books are reviewed in this issue.

Erratum: The news note on the expansion of the Alfred P. Sloan Foundation scholarship program [*Science* 124, 24 (6 July 1956)] stated that 11 institutions were already participating in the program, then named only 10. Carnegie Institute of Technology was accidentally dropped from the list, when actually it was one of the four institutions in which the Sloan program was started.

Erratum: The ninth Pacific Science Congress was incorrectly announced for 18 Nov.–9 Dec. 1956 [*Science* 124, 334 (17 Aug. 1956)]. The congress is to be held in Bangkok, Thailand, in 1957, not 1956.

AAAS Building Dedication

To celebrate the completion of its new headquarters building, the Association will hold a special meeting in Washington, D.C., on 12 October 1956. In keeping with the nature of the Association, the program will be devoted to a scientific topic: "The Uses and Effects of Atomic Radiation." All members of the Association and of the interested public are cordially invited. The meeting will be held at the Carnegie Institution of Washington, 16th and P Streets, NW.

Program

THE USES AND EFFECTS OF ATOMIC RADIATION

Chairman: Paul B. Sears, *President*

10 A.M.

Welcome

Caryl P. Haskins, *President, Carnegie Institution of Washington*

Radiation and the Human Body

Shields Warren, *Pathologist, New England Deaconess Hospital*

Radiation and Genetics

L. C. Dunn, *Professor of Zoology, Columbia University*

The Uses of Atomic Radiation and Energy

Lawrence R. Hafstad, *Vice President, General Motors Corporation*

2 P.M.

Social Implications of Atomic Radiation and Energy

Detlev W. Bronk, *President, Rockefeller Institute*

Current Research Findings

Willard F. Libby, *Commissioner, U.S. Atomic Energy Commission*

What We Most Need To Know

Laurence H. Snyder, *President-Elect of the Association* and *Dean of the Graduate College, University of Oklahoma*

Dedication of the American Association for the Advancement of Science Building

Paul B. Sears, *President of the Association* and *Chairman, Conservation Program, Yale University*

At the conclusion of the meeting, the Association will hold open house at its new building at 1515 Massachusetts Avenue, NW.

Reports

Immunologic Comparison of Isolated Surface Membranes of Bacillus megaterium

Recent advances in bacterial physiology have made possible the isolation and purification of cell walls, protoplasts, and cytoplasmic membranes (*1–3*). Separation of these structures from *Bacillus megaterium* permitted an immunologic comparison, attractively simple in concept, that provided data bearing directly on the antigenic difference between the two membranes, the structural nature of surface antigens, and the question of the ability of antibody globulin to penetrate the cell wall. Although this experiment is preliminary to continuing immunocytologic work with other isolated structures of *Bacillus* spp., the results seemed of sufficient general interest to warrant reporting.

Several other studies have been concerned with the antigenic relationship between isolated cell walls and intact or ruptured cells (*4*). The continuing work of Tomcsik (*5*) is especially pertinent for its detailed immunologic analysis of capsular, cell-wall, and protoplast materials of *Bacillus* spp.

Strain KM of *Bacillus megaterium* was selected because of its sensitivity to lysozyme and its potential for the separation of several cell structures. It was grown in 2-percent peptone broth at 30°C with aeration. Microscopic examination and other studies (*6*) have indicated the improbability that capsular material is present on cells grown and washed under the conditions of the experiment.

Cell walls were isolated essentially by the procedure of Salton and Horne (*1*). Protoplasts were prepared by the method of Weibull (*2*). Membranes were obtained by resuspending an aliquot of protoplasts in phosphate-sucrose buffer containing 0.01 molar Versene and approximately 10 μg of deoxyribonuclease (DNase) per milliliter. The mixture was allowed to react for 30 minutes at 37°C. Versene disrupted the protoplasts, providing protoplast membranes that apparently were more intact than those obtainable with distilled water. The DNase prevented the suspension from becoming gelatinous. The suspension then was recentrifuged at 12,800g for 10 minutes, and the pellet was resuspended in 0.85-percent saline (which was found to facilitate removal of small particles) and finally was washed five times in distilled water. When the resulting preparation was viewed by phase microscopy, delicate membranous structures, almost completely devoid of protoplasmic particles, were observed. These protoplast membranes, probably the equivalent of cytoplasmic membranes (*3*), contained 11.0 percent ribonucleic acid (RNA) by the orcinal reaction (*7*) but no deoxyribonucleic acid (DNA) by the diphenylamine reaction (*8*), using preparations that had not been treated with DNase. The membranes were lysed by wheat-germ lipase but not by lysozyme or ribonuclease (RNase). The preparation of cell walls contained no detectable granules, DNA, or RNA and were lysed by lysozyme but not by lipase or RNase.

Cell walls, protoplasts, protoplast membranes, whole cells, and lysozyme then were used as immunizing antigens. Three or four rabbits were employed for each preparation. The animals were inoculated intravenously three times a week over a period of 3 months. Preimmune serums were obtained initially. Immune serums were obtained at intervals of 3 weeks, after allowing the animals 1 week of rest from antigen inoculations. The antibody titers reached maximum and adequately high levels in 6 weeks; at this point the serums were pooled and used in the later tests.

At first, the conventional tube agglutination reaction was used in assaying the immunologic reactions. Subsequently, the 50-percent end-point method of complement fixation (*8*) was used as a more sensitive index to confirm the agglutination titers. Although lysozyme has been reported to be antigenic (*9*), serums from rabbits injected with an amount of lysozyme equal to that used in preparing protoplasts failed to react with lysozyme, protoplasts, or protoplast membranes. Similarly, the preimmune serums were negative to all test antigens.

Table 1 includes the results of a factorial comparison of the several preparations. These data were further substantiated by conventional adsorption tests, in which the antiserum was twice adsorbed with an excess of antigen to demonstrable completion. These results are shown in Table 2. The experiment suggested the following conclusions, which are presented topically with the supporting data.

1) The cell wall and the protoplast membrane are antigenically distinct. The heterologous reactions between cell walls and either protoplasts or protoplast membranes were negative (Table 1), findings that are in agreement with those of Tomcsik (*10*). Moreover, adsorption with cell walls of whole-cell antiserum did not reduce the titer to protoplast membranes (Table 2). The data also confirmed the purity of the isolated membranes and walls.

2) Injection of the whole cell stimulates antibody to the respective component structures. Antiserum to intact cells reacted with antigens of cell walls, protoplasts, and protoplast membranes (Table 1). This observation directly confirms a basic tenet of immunology.

3) The reactive "surface antigens" of the intact cell are those of the cell wall. Although flagellar and capsular antigens have been identified with known structures, the term *surface antigens* carries a degree of ambiguity. Conceivably, such surface antigens could represent only the peripheral structure (here, the cell wall) or the underlying protoplast membrane or both. The data in Table 1 appear to

Table 1. Serological reactions of whole cells and isolated structures of *Bacillus megaterium*. Titers determined by agglutination are given in parentheses above those determined by complement fixation. Lysozyme and other controls were negative.

Test antigens	Antiserum to: Whole cells	Cell walls	Protoplasts	Protoplast membranes
Whole cells	(2560)	(1280)	(< 10)	(< 10)
	20,480	5120	80	40
Cell walls	(1280)	(640)	(< 10)	(< 10)
	2560	5120	< 10	< 10
Protoplasts	(320)	(< 10)	(320)	(320)
	1280	< 10	1280	1280
Protoplast membranes	(160)	(< 10)	(320)	(320)
	1280	< 10	1280	1280

Table 2. Cross adsorption of antiserums to whole cells and cell walls of *Bacillus megaterium*. Titers were determined by complement fixation.

Test antigens	Antiserum to whole cells adsorbed with			Antiserum to cell walls adsorbed with		
	Whole cells	Cell walls	Control	Whole cells	Cell walls	Control
Whole cells	< 20	< 20	20,480	< 20	< 20	2560
Cell walls	1280	< 20	2560	1280	< 20	5120
Protoplast membranes	1280	1280	1280	< 20	< 20	< 20

identify the structural locus of such surface antigens with the cell wall alone. It was observed that antiserum to protoplasts or protoplast membranes did not react significantly with intact cells or cell-wall antigens, but that antiserum to cell walls did react with whole-cell antigens. Moreover, intact cells adsorbed only a portion of the antibodies to cell walls (Table 2).

4) Antibody globulin does not penetrate the cell wall. The literature on immunology and data on the apparent impermeability of bacteria to globulin molecules (*11*) have implied that antibodies to bacterial cells react only with antigens on the exterior of the intact cell and do not penetrate to deeper lying structures. However, experiments with fixed animal cells and tagged antibodies have indicated that penetration of antibody molecules into such cells may occur (*12*). In our experiment, antiserum to protoplasts or protoplast membranes in reactions with whole-cell antigens fixed complement to only a minimal degree (Table 1), suggesting that the cell wall is impermeable to antibody (if the assumption is valid that complement is at least as capable of penetration as antibody). The parallel agglutination tests appear to be inapplicable because of the necessity of spatial proximity for bonding of the reactants; this may not be realized because of the thickness of the cell walls. The conclusion is further substantiated by the observation that adsorption of whole-cell antiserum with whole cells or cell walls failed to change the titer against protoplast membranes, and that adsorption of cell-wall antiserum with whole cells removed only a portion of the antibodies to cell walls (Table 2).

Similarly, it was observed that lipase, although lytic to protoplasts or protoplast membranes, had no apparent effect on whole cells or on protoplast formation from lipase-treated, washed cells. Thus, both antibody- and enzyme-protein molecules, each having a specific affinity for the protoplast membranes, apparently are unable to penetrate the cell wall of this bacterium (*13*).

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Algae as Sources of Lysine and Threonine in Supplementing Wheat and Bread Diets

A shortage of protein in many parts of the world has stimulated studies of possible additional resources. Algae have received considerable attention because they can be grown with simple inorganic nutrients in mass culture, and many have a high nitrogen content (*1*). However, their nutritional value has received scant study. Combs (*2*) found that supplements of *Chlorella pyrenoidosa* improved growth and feed efficiency in chicks, an effect attributed to riboflavin, carotene, and perhaps other vitamins contributed by *Chlorella*. Henry (*3*) fed *Chlorella* to young rats and reported a protein efficiency ratio somewhat superior to peanut meal, about equal to brewers' yeast, but considerably inferior to dried skim milk. Bender *et al.* (*4*) found a variable but generally low protein value for several marine algae in rat studies.

Published values on the amino-acid composition of algae indicate a surprisingly good spectrum of essential amino acids, except perhaps for cystine-methionine (*1, 2, 5–7*). The threonine and lysine content of *Chlorella* is about the same as that of hen eggs (*6*). These facts prompted us to test algae as supplements in wheat diets, for lysine, threonine, and valine have been shown to improve wheat flour (*8*), and lysine (*9*) or lysine and threonine improve the nutritional value of enriched white bread.

In the first experiment, a green algae *Scenedesmus obliquus* WH-50 was mass cultured as described elsewhere (*10*), harvested, dried, ground to a powder and fed to weanling rats as indicated in Table 1. The results show that *Scenedesmus* improved growth significantly with both flour and bread diets. These effects can be attributed almost certainly to amino-acid supplementation. The flour diets were adequately fortified with all known required minerals and vitamins except vitamin B_{12}, which had no growth-promoting effect in parallel experiments. Although the bread diet was not so fortified, other experiments showed that vitamin and mineral supplements produced only a slight growth response with such diets. It is also clear that *Scenedesmus* was an excellent source of threonine (group 4 versus groups 7 and 3). A comparison of group 2 versus groups 1 and 3 suggests that *Scenedesmus* was contributing considerable lysine. However, a comparison of group 6 with groups 7, 2, and 3 indicates that the lysine content of *Scenedesmus* was not sufficient for a complete growth response. This may be due to the fact that lysine probably is more deficient than threonine in these diets. The supply of *Scenedesmus* was insufficient to test it at levels higher than 4 percent. The nitrogen content of this lot of *Scenedesmus* was not determined but was assumed to be equivalent to 50 percent protein, based on experience with other lots that were cultured under the same conditions (*11*). The growth effects produced by *Scenedesmus* cannot be explained as due simply to the addition of a source of amino nitrogen, for group 5 showed no growth response. Furthermore, in parallel experiments, supplementation with amino acids other than lysine and threonine did not produce a growth response with these diets.

Another green algae, *Chlorella pyrenoidosa,* which was cultured and prepared in the same way as *Scenedesmus,* and a different strain of weanling rat (Osborne and Mendel) were used in a second series of experiments. The nitrogen content of two different lots of *Chlorella* was 7.38 and 7.92 percent (dry basis). One test (five rats per group and

19 days of growth) was conducted, using the flour diet (Table 1) and increasing supplements of *Chlorella* to obtain some estimate of effective amounts. *Chlorella* at levels of 1, 2, 4, and 6 percent produced growth 1.3, 2.1, 2.3, and 3.8 times greater than that of animals receiving no *Chlorella*. An additional group in this series received the flour diet plus lysine and threonine and attained a weight 5.5 times greater than the groups that received no algae or amino acid. This suggests that *Chlorella* at the 6-percent level did not fully provide the lysine and threonine that was required under these conditions. A limited supply prevented the testing of higher concentrations of *Chlorella*. A similar experiment, in which all the flour diets were supplemented with lysine, also showed increasing growth with increasing levels of *Chlorella*. However the diets with 4- and 6-percent levels of *Chlorella* produced almost the same growth, the difference not being significant statistically. This result suggests that 4-percent *Chlorella* supplied about as much threonine as the rat could use under these conditions (with lysine added).

Lysine can be produced synthetically at modest cost. A lysine-enriched bread is being marketed experimentally. Threonine, however, remains very expensive. Therefore, additional experiments were conducted to evaluate *Chlorella* as a source of threonine in supplementing enriched white bread, and to compare algae with other sources of protein in this respect. These diets were supplemented with vitamins, minerals, fat, and lysine (except for one control group) to remove possible limitations on growth other than threonine. The first four groups in Table 2 indicate that *Chlorella* is an effective source of threonine in supplementing enriched bread, as judged by both growth and food efficiency. The experiment represented by the last seven groups was conducted at a different time than that represented by the preceding groups. The results are comparable, however, as indicated by the similar growth of the group in each series (96 and 94 g) that received a lysine supplement. The results indicate that *Chlorella* is a better source of threonine than purified soya protein and is equal to several animal-protein foods of high biological value when used as food supplements isonitrogenous to *Chlorella*.

These data indicate that algae protein may have considerable potential application as a source of amino acids that are generally low in cereals.

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Table 1. Effect of *Scenedesmus obliquus*, lysine, and threonine in white flour or bread diets. Each group consisted of 9 or 10 National Institutes of Health black male rats. Each rat was housed separately in a raised-bottom, wire-mesh cage. Diets were fed *ad libitum*. The flour diet consisted of commercial unenriched white wheat flour (92 g), starch (1 g), cottonseed oil (3 g), and HMW salts (4 g) (*12*). Each gram of starch contained added thiamine (0.2 mg), riboflavin (0.3 mg), pyridoxine (0.25 mg), pantothenate (2 mg), niacin (2 mg), folic acid (0.1 mg), biotin (0.01 mg), 2-methyl naphthoquinone (0.1 mg), inositol (10 mg), and choline chloride (100 mg). The 3 g of cottonseed oil contained added vitamins A and D (550 and 110 U.S.P. units, respectively) and α-tocopherol (5 mg). The bread diet consisted of commercial white enriched bread (3 percent dry skim milk solids) that was air dried and ground to a powder. No other vitamins, minerals, or fat were added.

Group	Diet	Weight gain in 27 days (g/rat)*
1	Flour	6.4 ± 0.6
2	Flour with 4% *Scenedesmus*†	20.3 ± 1.2
3	Flour with 0.75% lysine · HCl	25.0 ± 1.2
4	Flour with 0.75% lysine and 4% *Scenedesmus*†	53.2 ± 3.1
5	Flour with 1.2% DL-threonine	7.3 ± 1.0
6	Flour with 1.2% DL-threonine and 4% *Scenedesmus*†	18.6 ± 1.8
7	Flour with 1.2% DL-threonine and 0. 75% lysine · HCl	46.5 ± 2.9
8	Bread	22.0 ± 1.2
9	Bread with 4% *Scenedesmus*†	40.8 ± 2.6

* Standard error = range divided by number of animals (*13*).
† The algae replaced an equal weight of flour or bread.

Table 2. *Chlorella pyrenoidosa*, lysine, threonine, and various proteins as supplements in enriched white-bread diets. The rats tested were Osborne-Mendel male weanling rats. Each group contained ten rats, except the group that received *Chlorella*, which contained 5 rats. The bread diet contained air-dried commercial white enriched bread (3 percent dry milk solids) (92 g), HMW salts (4 g) (*12*), starch (1 g), and cottonseed oil (3 g). The starch and cottonseed oil provided vitamins in the same amounts as those listed in Table 1. The amino-acid and protein supplements replaced an equal weight of bread in the diets.

Diet	Weight gain in 28 days (g/rat)	Food efficiency*
Bread	14.8 ± 1.6	11.7
Bread with 0.75% lysine · HCl	96.3 ± 10.0	3.2
Bread with 0.75% lysine · HCl and 4% *Chlorella*	133.0 ± 8.4	2.9
Bread with 0.75% lysine · HCl and 1.2% DL-threonine	139.3 ± 5.7	2.6
Bread with 0.75% lysine · HCl	94.0 ± 1.7	3.6
Bread with 0.75% lysine · HCl and 2.1% casein	116.1 ± 4.0	3.1
Bread with 0.75% lysine · HCl and 2.1% soya protein	99.1 ± 5.9	3.5
Bread with 0.75% lysine · HCl and 2.9% dried liver	117.6 ± 4.3	3.2
Bread with 0.75% lysine · HCl and 5.4% dry skim milk	127.3 ± 3.8	3.0
Bread with 0.75% lysine · HCl and 4.9% whole dried egg	123.2 ± 8.4	2.9
Bread with 0.75% lysine · HCl and 1.2% DL-threonine	125.4 ± 4.2	3.0

* Food efficiency = grams of food eaten per gram of weight gained.

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19 July 1956

San Augustin Plains—Pleistocene Climatic Changes

The sediments of the former Lake San Augustin, Catron County, western New Mexico, afford a long and apparently continuous record of vegetation and climate (*1*). These deposits form the San Augustin Plains below the well-known Bat Cave, within a closed basin some 7000 feet above sea level and in a region of definite though irregular altitudinal belts of vegetation. The flora of this basin is now alkaline semidesert, with chenopods (*Atriplex* and *Sarcoba-*

tus) in the alkaline or heavily grazed areas and considerable short-grass (*Sporobolus*) on the flats and *Bouteleoa* on the surrounding uplands.

Above this grassland, as elsewhere in New Mexico, is the woodland zone of juniper (*Juniperus* ssp.) and piñon (*Pinus edulis*) whose nearest outliers reach the basin rim. The ponderosa pine (*Pinus ponderosa*) zone is still higher and farther away, except where it descends locally in occasional canyons or on sandy soil. On the highest elevations and in protected sites of the ponderosa pine belt may be found limber pine (*Pinus flexilis*), Douglas fir (*Pseudotsuga taxifolia*), and white fir (*Abies concolor*). Spruce (*Picea* ssp.), so far as is known, is confined to high elevations beyond the present limits of the basin drainage.

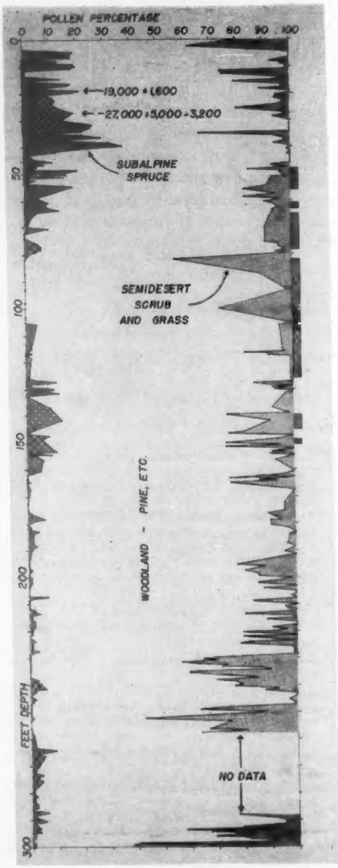

Fig. 1. Pollen profile from the San Augustin Plains, New Mexico. Percentages of nontree pollen, chiefly chenopods, composites, and grasses, are shown at the right of the diagram, and spruce at the left. The middle strip represents background, chiefly pine with some oak. Occasional sharp, temporary increases of aspen and juniper at the expense of pine, owing to drouth, fire, or other edaphic causes, are included as background but are not shown. Spruce "curve" is an approximate thermograph if it is read from right, falling where spruce is abundant (low temperature) and rising at spruce minima (high temperature). The nontree graph although incomplete, is an approximate measure of aridity. The depth scale is a function of time and rate of sedimentation. It is uncalibrated except where dates are shown.

Although this general pattern of zonation is subject to considerable local variation because of slope, soil, and exposure, any consistent shift in altitudes as indicated by the pollen profile should be evidence of temperature change. Specifically, any increase in spruce-fir pollen in basin deposits would indicate low temperature. In addition, the presence of lacustrine algae (not shown in Fig. 1) serves to indicate periods of moisture sufficient to maintain a lake in the basin. In times of greater aridity such lakes would become more saline and gradually dry up, with an increase in the semidesert vegetation.

Fir and Douglas-fir pollen are rare, presumably owing to limited distance of transport, while juniper, aspen, and oak appear only at intervals. Pine serves chiefly as background, because of its great altitudinal range and the difficulty of specific identification of piñon and ponderosa-pine pollen.

Figure 1 represents the pollen profile of the upper 300 ft of a 645-ft core, analyzed at close intervals (1 ft or less). An additional 120 ft, analyzed at 3-ft intervals, is not shown but is discussed in later paragraphs. Spruce (subalpine) percentages are shown in the shaded area at the left, nontree (semidesert) scrub and grass) in the shaded area at the right; the unshaded space between represents background, essentially pine but including a few other tree genera. On the assumption that the amount of spruce varies inversely with temperature, its graph, read horizontally, may be taken to represent the rise and fall of temperature. The crest of the nontree pollen graph, on the other hand, may be regarded as an essential measure of aridity.

The present vegetation of the basin is clearly reflected in the total absence of spruce pollen and in the abundance of chenopod pollen against a background of pine at surface level, 0 ft. From about 5 to about 70 ft, the abundance of spruce indicates a prolonged period of low temperature, with marked interruptions at about 12 and 52 ft.

There is another definite and prolonged interruption extending from about 70 to about 125 ft. Below this, at approximately 125 to 155 ft, there is another cold period, likewise showing interruptions. From 155 ft to the aforementioned 300-ft depth, spruce never reaches high proportions, although it shows slight but definite peaks at intervals. Preliminary analysis of the further 150 ft mentioned in a preceding paragraph gives no evidence of additional cold, high-spruce episodes down to 450 ft.

From 230 to 450 ft the nontree pollen contained significant amounts of sagebrush (*Artemisia*), but above 230 ft mainly chenopods (*2*).

On the assumption that low temperatures in this area accompanied glaciation, a group of glacial episodes appears to be represented in the upper spruce segment of the profile (approximately 5 to 70 ft). A carbon-14 date of 19,700 ± 1600 years at the 19-ft level has been determined (*3*), and a less reliable one (now being rerun owing to background difficulties) of 27,000 + 5,000 years or − 3200 years at the 28-ft level.

The upper series of glacial episodes appears to be separated from an earlier series (approximately 125 to 155 ft) by a nonglacial interval, while conditions below 155 ft appear to have been nonglacial to the depth of at least 450 ft.

As proper checks on this study, the vegetation and present-day pollen deposits of the San Augustin area are being investigated by Loren Potter and the sedimentary history is being investigated by Fred Foreman, who has supplied information on the sand layers shown in the graph. Since this sand may have accumulated rapidly, the interval between the two series of glacial episodes is of uncertain length. A further complication in this important segment (80 to 120 ft) is that there are considerable intervals between reliable counts, owing to pollen scarcity. There is no reason to doubt the consistent low percentage of spruce, but the graph of nontree pollen is highly generalized in this interval.

Laborious and exacting as this type of work proves to be, the results thus far obtained suggest that it should be continued by coring to the base of the sediments and that it should be extended to a number of the other lacustrine deposits in the Southwest. In this way a complete sequence for the Pleistocene and, perhaps by sufficient attention to details of nonglacial times, a better understanding of the fundamental characteristics of climate could be established (*4*).

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References and Notes

1. See the accompanying papers by C. E. Stearns and by F. Foreman in this issue.
2. Discussion of this and other interesting details must await later presentation.
3. This was accomplished through the courtesy of the Magnolia Petroleum Company.
4. Grateful acknowledgment is due to the division of earth sciences, National Science Foundation,

for its support of this project. Potter's work is being sustained by a grant from the division of environmental studies of the NSF, and to him we are indebted for advice on this paper. To Johs. Iversen special thanks are rendered for his wise and generous counsel.

1 June 1956

San Augustin Plains—the Geologic Setting

The San Augustin Plains occupy a high, intermontane basin on the continental divide in the Datil-Mogollon volcanic plateau of western New Mexico (*1*). Their general features have been described by Bryan (*2*) and Powers (*3*). At present, a playa occupies approximately 35 mi² at the west end of the plains. During the late Pleistocene at least, a maximum area of 255 mi² was occupied by pluvial Lake San Augustin. Postlacustrine erosion and sedimentation have produced only local and minor modifications of the features of the lake.

The highland areas bordering the basin are chiefly erosional remnants, carved in Tertiary volcanic rocks. Typical sections have been described by Powers (*4*), and I am currently engaged in more detailed studies of the sections in the northern half of the Pelona quadrangle for the New Mexico Bureau of Mines and Mineral Resources. Rock types range from rhyolite to basalt, and both flow and pyroclastic units are represented. Fluviatile and eolian beds are locally important. Thus, during most of the history of sedimentation in the basin, tributary streams have had continual access to a variety of types of volcanic rock. Significant variations in mineralogy of the basin sediments must be ascribed to variations in the surficial processes of erosion and deposition rather than to differences in the original character of source rocks exposed at various times.

The dissected flanks of two principal highlands on the south margin of the plains, O-Bar-O and Pelona Mountains, simulate the forms of broad lava cones. The basaltic lavas in these cones constitute the youngest volcanic unit that has been recognized in the north half of the Pelona quadrangle. They are probably as young as the Pliocene or Pleistocene.

The San Augustin Plains have the general form of a graben, although conclusive evidence of its origin has not been forthcoming. However, in several marginal areas, minor faults parallel linear segments of the topographic margins of the basin. These faults would be appropriate secondary members of fault zones, the principal displacements in which form structural boundaries to the basin. Near Bat Cave, late basalt flows peripheral to Pelona Mountain are broken by such faults. Thus, the San Augustin Plains appear to be a graben, the principal development of which postdates Pliocene or younger volcanics. No evidence was found of local volcanic activity contemporaneous to sedimentation in the graben.

The thickness of the unconsolidated sediments underlying the plains is known, from water wells, to exceed 1200 ft. If the graben is chiefly post-Pliocene (?), one would expect, as a first approximation, that the 645-ft core taken for detailed study would record, at most, the latter part of the Pleistocene. However, this approximation is extremely crude, and more precise inference of age must be sought in the core itself.

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References and Notes

1. See the accompanying papers by K. H. Clisby and P. B. Sears and by F. Foreman in this issue.
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21 June 1956

San Augustin Plains—the Sediments

The sediments from an almost continuous 645-ft core from the extinct Lake San Augustin are being studied (*1*). This old lake floor, elevation 6775 ft, is situated in the southwestern part of the San Augustin Plains of New Mexico. The drill site is near the center of the present playa, some 4 mi from the nearest slopes of the surrounding hills. It is believed that the sedimentation in this part of the lake was least affected by fluctuations of lake level or by deposits from any one stream and that, therefore, this core gives as good a picture of the general lake sedimentation throughout its length as could be attained with a linear series of samples.

Textural analyses, petrographic studies, and carbon dioxide determinations are being carried out, and, in the clay-sized particles, some *d. t. a.*, x-ray, and spectographic analyses have also been made.

The work to date shows that, if authigenic minerals are disregarded, the sediments are nearly all clayey silts, except for the interval between 45 ft and 215 ft, where there are alternating layers of sand and clayey silts. However, from 80 ft to 125 ft in this zone, the sand is almost continuous.

Carbonates, calcite, and dolomite are authigenic and are found in all samples of the core; the CO_2 ranges from 0.3 to 26.4 percent but is generally between 2 and 6 percent. These carbonates occur in all grade sizes, sometimes as single crystals, sometimes as aggregates, and they vary in color from clear to white to buff. The allogenic minerals are evidently those of the igneous rocks surrounding the basin; feldspar, hornblende, pyroxene, mica, olivine, and quartz are commonly found, and, except for the mica, these are generally fresh and angular. In some instances, rock particles, usually subangular to round, occur. These are usually of andesitic rock but range from rhyolite to basalt. The clay-size fraction consists of clay minerals (montomorillonite, nontronite, and allophane) and carbonate (calcite and dolomite) with small amounts of allogenic minerals, chiefly quartz and feldspar.

The only fossils found in these sediments are pollen, algae, ostracods, and rare opaline particles that may be diatoms. The sedimentation in this lake was probably slow, except for the sand horizons between 45 and 215 ft. This sand is widespread, as is shown by the wells in the lake floor, nearly all of which find their water between the 60- and 200-ft levels.

It would seem, then, that conditions of erosion and deposition were fairly constant, except when these sand layers were deposited, and their origin appears to be the result of more rapid erosion by the streams entering the basin.

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Reference

1. See the accompanying papers by K. H. Clisby and P. B. Sears and by C. E. Stearns in this issue.

13 July 1956

When our conceptions are clear and distinct, when our facts are certain and sufficiently numerous, and when the conceptions, being suited to the nature of the facts, are applied to them so as to produce an exact and universal accordance, we attain knowledge of a precise and comprehensive kind, which we may term Science.—WILLIAM WHEWELL, *The Philosophy of the Inductive Sciences* (1847).

Book Reviews

Noradrenaline. Chemistry, physiology, pharmacology and clinical aspects. U. S. von Euler. Thomas, Springfield, Ill., 1956. 382 pp. 88 illus. $11.50.

For many years the chemical transmitter of sympathetic nerve stimulation was considered to be adrenaline, the main sympathomimetic substance of the adrenal medulla. Many inferences regarding the physiology of the sympathetic nervous system have been drawn on the basis of experiments with adrenaline. Important dissimilarities between the actions of adrenaline and of sympathetic nerve stimulation soon became apparent, however, and led to the concept that an ambivalent transmitter "sympathin" was liberated which acquired either an excitatory or inhibitory action on various organs through combination with one or the other of the hypothetical receptor substances, E and I.

This thesis became unnecessary when Von Euler, in 1946, provided proof that noradrenaline, the demethylated analog of adrenaline, known for nearly 50 years as a chemical curiosity, is the predominant sympathetic transmitter. The discovery provoked an almost unprecedented burst of research throughout all parts of the world. Indeed, it is seldom that a compound has attracted so wide an interest in so short a time. This interest, of course, has been motivated by the important implications of the concept that the adrenergic mediator of the internal economy of the body is not adrenaline but a chemically related compound with significantly different properties.

The rapid development of this concept has necessitated a reappraisal of the physiology of the sympathetic nervous system. It is indeed appropriate that the appraisal should be presented by Von Euler in the form of a monograph on noradrenaline, for his brilliant studies have produced major advances in this important field.

Virtually everything on scientific record concerning the biochemistry, occurrence, and function of noradrenaline is recorded in this book. Some 750 references are cited, the majority of them referring to papers published since 1946. The scope of the monograph is evident from the content of the various chapters.

The first chapter gives a historical account of the scientific climate that finally led to the discovery of norepinephrine in the body and the viewpoint that it is the specific transmitter agent in adrenergic nerves. In chapter 2, a description of the chemical and physical properties of the adrenalines supplies useful background material for problems concerned with the isolation and assay of these substances. Chapter 3 is a short and lucid account of what is known and postulated about the steps and enzymes involved in the biosynthesis and metabolic fate of noradrenaline and adrenaline. Chapters 4 and 5 describe extraction procedures for the isolation of the adrenalines from tissues, and of measuring the concentration of one in the presence of the other by bioassay, chemical, and fluorescent methods. These chapters are particularly rewarding to workers undertaking the sometimes difficult problem of assaying noradrenaline and adrenaline.

Chapter 6 deals with the proof that noradrenaline as well as adrenaline is a constituent of the adrenal medulla and the implications thereof. Thus, it has been present all these years, entirely unsuspected, in the preparations of "adrenaline" prepared from animal adrenal glands! The remarkable species variation in the relative amounts of the adrenalines in the adrenal glands is discussed. For example, the rabbit and the baboon have virtually no noradrenaline, and most other mammals including man contain only a small percentage of noradrenaline in their adrenals. The cat and the lion contain a considerable fraction of noradrenaline, leading to the interesting concept that felines with their peculiar type of activity, typically one of sudden attacks, require the release of the potent vasoconstrictor noradrenaline to maintain blood-pressure homeostasis.

Of particular interest are the adrenal glands of certain whales which contain noradrenaline almost exclusively. Is this because the whale had no need for the apprehension induced by epinephrine since it had no natural enemies until man and his harpoon appeared? Recent evidence is cited in this chapter for the exciting concept that the adrenal medulla as well as certain other parts of the body have two different kinds of chromaffin cells, one manufacturing noradrenaline and the other adrenaline. During early fetal life, the chromaffin cells in rats and in man are mainly noradrenaline producers. The proportion of adrenaline steadily increases, even beyond the time of birth, perhaps in preparation for the stressful situations found after the fetus leaves the security of the womb.

Chapter 7 describes the distribution of norepinephrine in peripheral nerves and in the various organs and includes a discussion of the mode of storage of the hormone in nerve terminals.

Chapter 8 is concerned with the level of the adrenalines in blood and other body fluids under normal and stressful conditions. This chapter indicates the difficulty of accepting many of the values in the literature for the concentration of noradrenaline and adrenaline in blood, when the specificity of the analytic method has not been appraised.

To many readers, chapter 9 will be the core of the book. It compares in detail the pharmacological actions of noradrenaline and adrenaline both *in vitro* and *in vivo* and makes it apparent that, while the responses to the two compounds may be qualitatively similar in particular organs, there are qualitative and quantitative differences that create a reaction pattern that is quite distinct for the body as a whole. The marked vasoconstrictive effects of noradrenaline compared to the effects of adrenaline makes the former compound peculiarly fitted for its role as a transmitting agent, while adrenaline, by dilating the blood vessels of skeletal muscle and of the coronary arteries, by increasing the force and output of the heart, and by mobilizing the carbohydrate stores of the liver, best fits the role of a hormone secreted in situations of emergency.

Current theories on the mechanisms of action of noradrenaline and adrenaline are described. While speculations are not lacking, the biochemical nature of the actions of the compounds is still obscure. In fact, it is not even known whether the receptors for excitatory and inhibitory actions are the same or different. A detailed comparison is made in this chapter of the inhibitory effects of the various classes of adrenergic blocking agents on the actions of noradrenaline and adrenaline.

Chapter 10 particularizes the value of the evidence that norepinephrine is the actual adrenergic nerve transmitter released at postganglionic sympathetic nerve endings.

The various factors that evoke the secretion of adrenaline and noradrenaline from the adrenal glands are taken up in chapter 11. It is especially interesting that the ratio of adrenaline to noradrenaline in the secretion may differ from that in the gland. For instance, splanchnic nerve stimulation evokes mostly adrenal-

ine, while stimulation of the hypothalamus results in a variable ratio of noradrenaline to adrenaline that depends on the location of the stimulus. The implication that there are specific centers in the brain for the release of adrenaline or noradrenaline from the adrenal medulla raises the question of their function.

Chapter 12 is an account of the urinary excretion of noradrenaline and adrenaline normally and during various diseases and physiological situations. Tumors of adrenal medullary tissue and the evidence that the main pressor substance in the chromaffin cells of these tumors is noradrenaline are described in chapter 13.

Of particular interest to the physician and to investigators in cardiovascular research is the last chapter, which describes the therapeutic implications of the ability of noradrenaline to raise blood pressure without materially increasing the cardiac output. Many potential uses, including the support of blood pressure in certain types of shock and in operative and postoperative hypotension, are cited.

The difficult task of bringing together a huge mass of scattered data has been superbly accomplished, and the result is a book that is simply and interestingly written. The unsolved problems in the field are clearly and provocatively defined, and the plethora of suggestions for future research will be appreciated by young investigators. It cannot fail to be of interest to the biochemist concerned with the biochemistry of function, and it is virtually indispensable to the physiologist and pharmacologist working on fundamental mechanisms of the autonomic nervous system and to the physician who is curious how drugs interact with the nervous system.

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The Changing Universe. The story of the new astronomy. John Pfeiffer. Random House, New York, 1956. 243 pp. Illus. $4.75.

This is the first popular-level book on radio astronomy, and it is a good one. In fact, it is very good. The author has taken unusual pains to become thoroughly conversant with this new science, aided by two successive Guggenheim Fellowships. He has visited many of the radio astronomers in England, Netherlands, France, Canada, and the United States. He has used every available opportunity to talk with Australians visiting this country and has corresponded extensively with most of the others. In one way or another, he has been in contact with nearly 100 scientists working in this field.

Pfeiffer begins by telling the story of Karl Jansky's discovery of "cosmic static" in 1931 at the age of 26, and of his failure to secure support for continued pure research at Bell Laboratories. "Rarely in the history of science has a pioneer stopped his work completely, at the very point where it was beginning to get exciting. Yet Jansky did just that . . ." Industry has developed a more enlightened attitude toward pure research during the past 25 years, but this has not prevented us from lagging far behind other countries in the development of radio astronomy. It is noteworthy that the first large research facility to be supported by the National Science Foundation, and with specific Congressional approval, is a Radio Astronomy Observatory to be located near Green Bank, West Virginia.

The book continues with Grote Reber's pioneer researches, all paid for out of his own pocket and done on his own time. In 1937 Reber built in his backyard a radio telescope 31 feet 5 inches in diameter, and in October 1938 he made his first successful observations. He confirmed Jansky's discovery of the Sagittarius source, and he also found other sources in Cygnus, Cassiopeia, and elsewhere. He also found that radio waves are not coming from the brightest stars one can see in the sky. "The implication of this notion is sensational. It means that the universe contains things never before observed. There are unique objects in the radio skies, objects whose light—if any—is too faint to see and which we can know only through their radio waves."

Wartime developments in radar and electronics have been helpful in accelerating the advance of radio astronomy. Reber tried to detect radar signals reflected from the moon, but without success. Signal Corps engineers did this with ease after World War II, using more advanced equipment.

The remainder of the book describes results from all branches of radio astronomy: solar, planetary, meteor, galactic, extragalactic, and the radio sextant. The concluding chapter, entitled "The future," describes some of the equipment now in the planning stages and ends with a discussion of the cosmologic problems that may be solved with the aid of radio astronomy.

The drawings of Sol Ehrlich add much to the attractiveness of the book. However, an old-fashioned optical astronomer, such as I am, cannot accept the implication of the drawing on page 220, which shows the Palomar Observatory draped with cobwebs. The apparent division between radio astronomy and optical astronomy is an artificial division due to technology, and it is all just plain unmodified *astronomy* as far as the basic problems and goals are concerned. A more likely picture would show two Palomar Observatories working twice as hard trying to keep up with the new problems being brought in by radio astronomy.

FRANK K. EDMONDSON
National Science Foundation

New Lives for Old. Cultural transformation—Manus, 1928–1953. Margaret Mead. Morrow, New York, 1956. 548 pp. Plates, $6.75.

"The mid-twentieth century is an emergency for humankind . . . . Peasant, feudal, and primitive economies [are] crumbling before the onset of new ideas and new technologies. Traditional faith and traditional practice [are] disappearing. What [is] happening to those who [are] asked to skip centuries in the way they ordered their lives? How [do] these rapid changes inevitably involve those individuals who [live] through them in disturbances of personality which would leave their mark on society for many generations to come?" Accepting the challenge of these facts and questions, Margaret Mead decided that ". . . the most pressing problem, in the range of problems which anthropology was equipped to attack, seemed . . . to be how change occurred within a single generation." And so deciding, she spent 7 months living with "a people who have moved faster than any people of whom we have records, a people who have moved in fifty years from darkest savagery to the twentieth century, men who have skipped over thousands of years of history in just the last twenty-five years"—the Manus.

This was not her first experience with this small group of Melanesians; 26 years before, she had lived with them and consequently had written *Growing Up in New Guinea*, a standard reference for social scientists in particular and for a startlingly large lay audience in general. It was indeed a felicitous circumstance that such a careful scientist and lucid writer should have been an intimate observer of this profoundly important human "quantum jump" both before and after its occurrence.

And what has been this change? "Today they are friendly, where formerly they would have been harshly competitive; they are actively concerned with the prevention of types of behavior which they would formerly have regarded as natural and desirable; they are relaxed and unworried where they would formerly have been tense; they are rearing their children with a kind of indulgence

which would have been unheard of twenty-five years ago." This short summary, of course, does no justice to the review and analysis of old and new Manus behavior, values, and material ways of life which the book provides in fascinating detail.

But the detail is not the primary purpose of Mead's study. Rather her purpose is to use these "before-and-after" data to test and expand the theories of present-day social science regarding the interplay and interrelations of personality, character, and social organizations and institutions in order to better understand the process of social change and its consequences for mankind in these times of change.

"The Manus experiment itself is unique. The Manus were a people most favorably inclined toward change, conscious that cultural forms differed and could be changed, infused by their upbringing with an aspiration congruent with the more universal and humane forms of Western democracy, with the rare accident of a very gifted leader, and the unique experience of having a million men, members of a modern society intent on their own affairs, enact a large part of the pattern of Western democracy before their eyes." But all experiments are unique; it is the understanding of the variables and parameters which provides the basis for generalizations and new insights. And so too here. What in the upbringing of the Manus made them receptive to democratic values? What inclined them toward change? What were the characteristics of the leader, Paliau, —"speaking in a language which was not his mother tongue . . . [leading] a stranger people whose spirit he admired extravagantly . . ."—what were his characteristics which played an absolutely crucial role? Why was the advent of the American army basic to a basic change in the Manus?

The answers are complex and by no means only in the historical sense of complexity. They are complex because of the complexity of the dynamics of the interplay between persons and their social order. And it is precisely because Margaret Mead utilizes our *systematic* understanding, as we have it today, of these processes that this unique Manus experiment provides generalizable knowledge that is applicable to other circumstances of social change in being and yet to come. For example: "Whenever a people wish to take over some invention or discovery or practice of another people, the real alternatives should be seen as between taking over the new idea in the most abstract form possible, so that it may be incorporated within the old pattern with a minimum of change, or else taking over as much of the culture in which the new idea is imbedded as possible." There are convincing reasons for this argument which can only be adequately (as contrasted to "commonsensely") understood after reading her book. They are so convincing that it behooves, for example, those who plan to bring atomic power to other cultures to plan, even more carefully than they plan their reactor designs, their social designs.

By writing *New Lives for Old* in the way she has, Mead has made a twofold contribution; not only has she substantially added to our understanding of the process of social change and to an understanding of the techniques which will help facilitate it in a humanitarian and stable manner, but she has provided an additional important by-product for realizing our own efforts to create for ourselves new lives for old. Our own social change—if it is to be salubrious—depends in significant part on the mutual understanding of our natural and social scientists.

Mead has deepened this understanding by providing a convincing refutation to the often smug assumption on the part of many "natural" scientists that the social sciences are after all a fuzzy collection of insightful, but still common, sense. Her careful reexamination of her understandings, misunderstandings, and ignorance of the significance of her 1929 data in the light of 1955 theory, and her careful application of the factual knowledge on personality and social dynamics accumulated in the intervening years, are in the best scientific tradition. There can be few readers indeed who will continue to perceive her exposition of the nature of social change, in terms of the relationship between social institutions and personality, as less than scientific in manner and means. As always in science, her conclusions are incomplete, and new unanswered questions emerge. But her enthusiasm and optimism, as they have in the past, will stimulate others to join her in the search for more and better answers.

DONALD N. MICHAEL
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The Pursuit of Science in Revolutionary America, 1735–1789. Brooke Hindle. Published for the Institute of Early American History and Culture, Williamsburg, Va., by the University of North Carolina Press, Chapel Hill, 1956. 410 pp. $7.50.

Science in the British colonies of America, and its continuation during and after the Revolution, long a neglected subject, has received considerable attention during the last quarter of the century. The objectivity of the research itself has not been without a certain subjective end: it had to be shown that the colonies were not, as was sometimes believed, only an intellectual backwater of the growing empire, but that they could hold their own with the mother country itself. Monographs are now plentiful, books have devoted chapters to some aspects, and our respect for colonial science has increased. The early antics of the American Philosophical Society and Bartram's travels have become as recognized and entertaining a part of American history as the Boston Tea Party. But a full study in book form was missing, and this gap has now been admirably filled by Brooke Hindle's book.

Hindle has not just compiled a book out of the existing monographs. He has gone over the whole field anew, searching at the sources, reading unpublished, as well as published, forgotten, as well as remembered, material, extending his studies into the first years after the Revolution. The source material consulted in different libraries is impressive. Years of work have gone into the gathering alone.

His final year is 1789, a convenient date to separate the mercantilist from the industrialist period. We are now able to see in detail the story of British colonial and revolutionary science unfolding, and make the acquaintance of the "natural history circle," the naturalists and physicians, teachers and travelers, experimenters and theoreticians of the period. We meet Bostonians, Philadelphians, Charlestonians, the circle around Franklin, Rust and Bartram, the founders and early members of the American Philosophical Society and of other clubs. Due emphasis is placed on the transit of Venus of 1769, the first organized scientific effort in the colonies, and in which their astronomers showed that they were worthy colleagues of their European associates. The last section of the book. "The new nation," lets us have a look at the physicians during the Revolutionary War, the attempts at natural history and natural philosophy in the young republic, and includes the early experiments with steamboat and balloon. There are many and interesting illustrations.

This book is truly an achievement and throws new light on the forces that made American intellectual history. Will the manner in which the author conceived his task always satisfy his readers? I, for one, with all appreciation for the precious wealth of information contained in the book and its careful arrangement, would gladly have missed some of the minor facts in order to obtain a better understanding of the true highlights of this American science, of those works that were real contributions to the world's science or technique. Such contributions

existed, and we do not just mean Franklin's—for instance, there was Godfrey's quadrant, a predecessor of the sextant, and Croghan's treasure trove of bones near the Ohio, one of the beginnings of paleontology. All these facts are mentioned in the book, but just as facts among many others. The emphasis is not always there.

The reader will thus occasionally have to do his own evaluation, and I believe that he will be richly rewarded for his efforts. I hope that a similar thorough labor of love and perseverance will one day be done for French Canadian science and for the science of New Spain—both necessary for a correct understanding of American mercantilist science as a whole.

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Techniques Générales du Laboratoire de Physique. vol. 1. J. Surugue. Centre National de la Recherche Scientifique, Paris, 1955. 671 pp. Illus. F. 2,400.

The graduate student embarking on a research career in experimental physics usually has had little experience in laboratory techniques and instrument design. Formal courses to fill this gap are not always available, and recourse to the literature is often the only means of obtaining the necessary information for the solution of experimental problems. The same need will confront the experienced researcher who leaves his field of specialty and borrows methods from related fields with which he is less familiar.

Although some textbooks on laboratory techniques are available, it is interesting to read a French treatise on this important subject, for the approach and techniques vary greatly from country to country. The volume here reviewed, which is published by the French equivalent of the U.S. National Science Foundation, consists of ten chapters written by different authors who are specialists in their respective fields. As might be expected, the chapters vary in clarity and approach, and no attempt seems to have been made to assure complete coverage of all the techniques used in physics. On the other hand, I noticed a great deal of valuable information not easily available elsewhere. I was particularly impressed with the first chapter, on general principles for the construction of scientific apparatus, in which precise theoretical discussions on the stability of mechanical systems and on deformation theory are mixed with practical advice on precision techniques for use of the lathe and milling machine. The next two chapters on glass blowing and vacuum techniques do not differ substantially from similar chapters in English texts, while the fourth chapter on production and measurement of high temperatures is very detailed—almost 100 pages—and contains many tables and theoretical discussions. The next three chapters deal with the general subject of optics, with emphasis on the properties of optical materials, the mounting of optical components, the alignment of optical systems, and other optical techniques not very familiar to the average experimenter. The treatment of light sources, filters, and photoelectric cells is complete and up to date, including discussion of lead selenide and lead telluride cells and of phototransistors. Chapter 8 gives a general description of recording techniques, while Chapter 9 deals with the regulation and rectification of electric currents. The last chapter gives an exhaustive treatment of electronic circuitry from a theoretical and experimental standpoint, but I regret the absence of any reference to transistors.

There are numerous subjects of interest to experimental physicists which are not treated by the authors of this volume, such as techniques of atomic and nuclear physics or calorimetry or low temperature physics. There are also important omissions within the areas covered. A more detailed index, and more liberal use of references would have improved the usefulness of the work even more. The work does not deal with fundamental principles and methods of measurement, systems of units of physical quantities, or theory of errors. Within its scope, however, it provides refreshingly clear and comprehensive information, and it is hoped its designation as volume 1 indicates the existence of plans for additional volumes that will handle the subjects omitted here with the same elegance, precision, and detail as is manifested in the treatment of the subjects of this volume.

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Office of Naval Research

New Books

Annual Epidemiological and Vital Statistics, 1953. pt. 1, *Vital Statistics and Causes of Death;* pt. 2, *Cases of and Deaths from Notifiable Diseases.* World Health Organization, Geneva, 1956. 571 pp. $10.

United States Army in World War II. The Technical Services. The Medical Department: Hospitalization and Evacuation, Zone of Interior. Charles McKittrick Smith. Office of the Chief of Military History, Dept. of the Army, Washington, D.C., 1956 (order from Supt. of Documents, GPO, Washington 25), 503 pp. $4.

The Trickster. A study in American Indian mythology. Paul Radin. Philosophical Library, New York, 1956. 211 pp. $6.

Abacs or Nomograms. An introduction to their theory and construction illustrated by examples from engineering and physics. A. Giet. Trans. and revised by J. W. Head and D. H. Phippen. Iliffe, London; Philosophical Library, New York, 1956. 225 pp. $12.

Television Engineering, Principles and Practice. vol. II, *Video-Frequency Amplification.* BBC Engineering Training Manuals. S. W. Amos and D. C. Birkinshaw. Iliffe, London; Philosophical Library, New York, 1956. 270 pp. $15.

Facing the Atomic Future. E. W. Titterton. Macmillan, London, 1956 (order from St Martin's Press, New York). 379 pp. $5.

The Petroleum Refinery Engineer's Handbook. J. F. Strachan. Philosophical Library, New York, 1956. 168 pp. $15.

Miscellaneous Publications

(Inquiries concerning these publications should be addressed, not to Science, but to the publisher or agency sponsoring the publication.)

Venereal Diseases. A survey of existing legislation. 44 pp. $0.70. *Expert Committee on Psychiatric Nursing, First Report.* WHO Tech. Rept. Ser., No. 105. 43 pp. $0.30. *Joint FAO/WHO Conference on Food Additives.* Geneva, 19–22 Sept. 1955. WHO Tech. Rept. Ser., 107. 14 pp. $0.30. *Expert Committee on Biological Standardization, Ninth Report.* WHO Tech. Rept. Ser., No. 108. 20 pp. $0.30. World Health Organization, Geneva, 1956.

Services Available to Industry in New Jersey. A list of representative sources of advice and assistance to New Jersey industry for aid in solving industrial problems. Ruth Bates Ahrens and Robert K. Bogardus. Bur. of Engineering Research Bull. No. 38. Rutgers University, New Brunswick, N.J., 1956. 94 pp.

British Association for the Advancement of Science, Annual Meeting. Sheffield, 29 Aug.–5 Sept. 1956. The Association, London, 1956. 103 pp.

The Strength to Meet Our National Need. A statement approved by representatives of the constituent member organizations of the American Council on Education on 20 Mar. 1956, for presentation to the President's Committee on Education beyond the High School, together with major addresses presented at the conference and other pertinent material. Charles G. Dobbins, Ed. American Council on Education, Washington, 1956. 125 pp. $1.50.

National Leadership Development Conference in Trade and Industrial Education, Conference Report. Fort Collins, Colo. 1–12 Aug. 1955. Circ. No. 477. U.S. Department of Health, Education, and Welfare, Office of Education, Washington, 1956. 118 pp.

Current Literature on Venereal Disease. An annotated bibliography (special issue). *First International Symposium on Venereal Diseases and the Treponematoses.* U.S. Department of Health, Education, and Welfare, Public Health Service, Washington, 1956. 164 pp.

Meetings and Societies

New York Meetings of the AAAS; 1887–1956

The 123rd meeting of the American Association for the Advancement of Science this coming 26–31 December, is also the seventh New York meeting. The previous New York meetings were held in 1887, 1900, 1906, 1916, 1928, and 1949. A brief comparison of the meetings indicates not merely the growth of the Association and the societies that participate but also provides an interesting indication of the shifts in emphasis in scientific research. The city's own development over 70 years, the influence of the times and of great personalities of the past are quite apparent in the programs and proceedings of the earlier conventions.

For some years the AAAS postponed a New York meeting because it was considered that the scientific population was smaller than in other centers. The first New York meeting, held 10–16 August 1887 at Columbia College, proved, however, to be a worth-while "experiment," and "the fear of hot weather [was not] fulfilled." There were 729 registrants from 31 states, Washington, D.C., and Canada, and 250 papers were read. Most of the sessions of the eight sections were held in Columbia's Hamilton Hall, then at 49 Street and Madison Avenue, and the "Programme" appropriately had a light blue cover. Samuel P. Langley, great physicist of the Smithsonian Institution, was president of the Association, which at that time had 1956 members; the retiring president's address, given by Edward S. Morse, summarized the many contributions of American zoologists to organic evolution during the preceding decade. F. W. Putnam was permanent secretary of the Association. The general chairman was F. A. P. Barnard, Episcopal clergyman and astronomer, president of Columbia, who had been president of the Association 21 years before, in 1866. The local committees of more than 500 prominent persons included Chauncey M. Depew, J. Pierpont Morgan, and Theodore Roosevelt.

Among the several participating organizations, the Torrey Botanical Club sponsored a field trip on Staten Island and a reception on the campus. The evening lecture, "The heart of Africa," by Henry Drummond of Glasgow, Scotland, was followed by a general reception for the Association with the New York Academy of Sciences as host.

After an interval of 13 years, the second New York meeting, 25–30 June, 1900, was held at Columbia University, which by then had been moved to its present location on Morningside Heights. The headquarters hotel was the Majestic at 72 Street and Central Park West, where the rates were "$1.50 and upwards." The local committee, composed of all AAAS members within a 25-mile radius of the city and headed by J. J. Stevenson, together with the AAAS Council, announced their intention ". . . to reduce the excursions and other social features . . . so prominent at many previous meetings, to such a point that there [would] be no possible interruption to the scientific sessions. . . ." In this they were but partly successful. Fifteen societies participated, including two that had also met the two preceding days, and 253 papers were read. Although the official registration was only 447, it was estimated that some 300 other scientists were present, making the combined attendance of the AAAS and the societies about as large as usual. R. S. Woodward, Columbia mathematician, was the 52nd president of the Association, and L. O. Howard, eminent entomologist, was the permanent secretary. The retiring president's address, "Rhythms and geologic time," was given at the American Museum of Natural History by Grove K. Gilbert, who had succeeded his fellow geologist, Edward Orton, the third AAAS president to die in office. At this meeting resolutions were passed in favor of preserving the redwoods of California, creating a national forest reserve in the southern Appalachians, and establishing a National Bureau of Standards. The Council's action in making *Science,* owned and edited by J. McKeen Cattell, an official journal of the Association, included with the dues, was destined to result in a rapid increase in AAAS members from the static figure of 1925 that year. A new section on physiology and experimental medicine was authorized.

The third New York Meeting, once more at Columbia, was held 27 December 1906 to 2 January 1907. Again J. J. Stevenson served as general chairman, and J. McKeen Cattell was secretary of the local executive committee. The full local committee consisted of all members within a radius of 50 miles. The permanent secretary, L. O. Howard, asked for the early submittal of titles because an effort was to be made to publish the entire program prior to the opening date; many titles, however, came in late. Hotel headquarters were at the Belmont across from Grand Central Station; the special rates to AAAS members for single rooms were $3 with bath, $2.50 without. There was now a subway, the trains of which, in this pre-shuttle period, ran directly to Columbia University. In the 6 years since the previous New York meeting, the Association, with 4498 members, had more than doubled in size; 19 societies participated, and 360 papers were read. The authors included virtually all the prominent scientists of the day and many younger men who were destined to achieve lasting recognition. Genetics was becoming a science in its own right. In most fields, experimental work was taking the lead over purely descriptive observations.

At this meeting, there were 934 who registered, and the total attendance was "conservatively estimated" at not less than 1500 scientists, which would make it the largest AAAS meeting up to that time. W. H. Welch, noted medical scientist from Johns Hopkins, took the gavel of the presidency of the Association from Calvin M. Woodward, mathematician, whose retiring address was "The science of education." Principal of the numerous social events was the reception that followed, given by the president of Columbia, Nicholas Murray Butler, in Earl Hall. Another feature of the meeting was the unveiling of ten busts of pioneer American scientists which were presented by Morris K. Jesup to the American Museum of Natural History. In addition to the sessions at Columbia and at the Museum, some sessions were held at the New York Botanical Garden and in the new building of the Rockefeller Institute for Medical Research. A new section on education was approved.

It was at the third New York meeting that the present Botanical Society of America was founded, on 27 Dec. 1906, by the merger of several botanical societies. The golden anniversary of the society will be appropriately celebrated at the 1956 New York meeting on the same day in December.

The Association's 69th meeting—the fourth New York meeting—26–30 December 1916, was described by J. McKeen Cattell as "the largest and most important gathering of scientific men hitherto held in this country or elsewhere." Twelve sections and 52 societies

participated, and 1252 papers were read. The registration was about 2100, and the total attendance was estimated as perhaps 8000; in 10 years AAAS membership, approximately 11,000, had more than doubled. Although the meeting was held principally at Columbia and at the American Museum of Natural History, numerous other sessions were widely scattered because of the preferences of so many societies. In addition to the Belmont, once again AAAS headquarters, the Astor, Waldorf, Biltmore, and seven other hotels were used.

World War I was in its third year in Europe, and a number of the programs reflected the emotions of the period. The symposium of the American Society of Naturalists, for instance, was "Biology and the national existence," and several vice-presidential addresses referred to preparedness. Two public lectures were given: A. A. Noyes of Massachusetts Institute of Technology spoke on "Nitrogen and preparedness," and Simon Flexner, in this epidemic year, spoke on "Infantile paralysis and the public health." The AAAS retiring president's address, "The nebulae," was given by astronomer W. W. Campbell; president Charles R. Van Hise, prominent geologist, presided. Henry Fairfield Osborn was general chairman, and L. O. Howard was still permanent secretary. A feature of the meeting, at the Engineering Building, was the symposium, "The interrelations of engineering and science," jointly sponsored by the ASCE, AIME, ASME, and AIEE. The scientific exhibits in University Hall attracted much attention.

During the 1920's the AAAS inaugurated a plan to make every fourth meeting, to be held in a major city, a particularly large and diversified one. The fifth New York meeting of 26 December 1928 through 2 January 1929 was the second in this pattern. With a registration of 3935—AAAS membership then stood at 16,328—and several thousand other scientists who attended, this 85th meeting of the Association was exceeded only, and then but slightly, by the 1924 meeting in Washington, D.C. On the programs of the 15 sections and 45 societies that participated were more than 2000 papers. The approximately 250 sessions once more were held principally at Columbia University, but the American Museum of Natural History, the Metropolitan Museum of Art, the headquarters of the American Geographical Society, and the Engineering Building were also used rather intensively. Despite the size and complexity of the meeting, however, it was exceptionally well organized and successful. Henry Fairfield Osborn, president of the American Museum of Natural History and current president of the Association, took an active personal interest, and the 11 local committees were under the able leadership of George B. Pegram of Columbia. The General Program of 344 pages was edited for the Association by Sam F. Trelease of Columbia; the permanent secretary of the AAAS, Burton E. Livingston, was ably assisted by Sam Woodley, in charge of meeting details, by H. S. Kimberley as exhibit manager, and by Austin H. Clark, who directed the Press Room.

The meeting was memorable for an unusual number of social events and general evening sessions, which included the AAAS presidential address of A. A. Noyes, "The story of the chemical elements"; the seventh annual Sigma Xi lecture, "What is light?" by Arthur H. Compton; and an address, "The scientific retrospect," by the noted astronomer, H. H. Turner, official representative of the British Association for the Advancement of Science. Other evening speakers were C. E. K. Mees, Charles P. Berkey, C. A. Kofoid, Franz Boas, W. M. Wheeler, and Harlow Shapley. Daily teas at Columbia, five receptions at the American Museum of Natural History, a Sunday largely devoted to tours of the city's scientific institutions, and an endowed, complimentary concert by the New York Philharmonic Orchestra added to the enjoyment of the registrants. The sixth AAAS Thousand Dollar Prize was awarded to Oliver Kamm for a paper on pituitary hormones, which was read before Sections C and N. Thirty-six commercial exhibitors participated in the Association's fifth official Exhibition of Science.

The sixth New York meeting—the 116th AAAS annual meeting—26–31 December 1949, was delayed for 21 years through a combination of circumstances that included World War II and the Centennial Meeting of the preceding year. It was by far the largest meeting in the long annals of the Association. Sixteen sections and 61 societies—including groups in the social fields which seldom meet with the AAAS—participated, and many of these experienced a larger attendance than they anticipated. There were 398 sessions (294 with projection) in 63 rooms, one-third of these on the campus of Columbia University, the others in the same Penn Zone hotels as the 1956 meeting. Registrations were 7014, but very probably at least another 12,000 attended some phase of the meeting. In addition to every section of the nation, 30 foreign countries were represented. The American Museum of Natural History was the site of a particularly pleasant Biologists' Smoker. The 102nd president of the Association was Elvin C. Stakman. The AAAS presidential address, "Ten million scientists," which pointed out the pleasures and importance of scientific observations by laymen, was given by Edmund W. Sinnott. Joseph W. Barker was general chairman, and the administrative secretary, who had just succeeded F. R. Moulton, was Howard A. Meyerhoff. It was the first AAAS meeting for the arrangements of which I was responsible.

Among the outstanding features of the meeting were the address on infrared studies by G. B. B. M. Sutherland, official representative of the British Association; the Sigma Xi address, "Evolution in the tropics," by Th. Dobzhansky; the first RESA address, "Recent advances in nuclear physics," by John R. Dunning; the lecture and film of the National Geographic Society on Arnhem Land by Frank M. Setzler; and the Josiah Willard Gibbs lecture of the American Mathematical Society by Norbert Wiener, "The mathematics of sensory prosthesis." Nuclear physics and engineering, the adrenal cortex, and television were the subjects of prominent and timely symposia. The 22nd AAAS Thousand Dollar Prize was awarded to Armin C. Braun for a paper on the tumor-inducing principle in crown gall, which was read before the American Phytopathological Society; the winner of the sixth Theobald Smith award, given by Eli Lilly and Company, was Seymour S. Kety of the University of Pennsylvania School of Medicine. The 26th edition of the Annual Exposition of Science and Industry, with 68 commercial exhibitors, was substantially larger than ever before. A feature, new since the previous meeting—the AAAS Science Theater—was popular throughout the period.

In summary, the records of all previous meetings in New York do not fail to mention the warm spirit of hospitality and interest in the Association and its work shown by the people of this great city.

In the 7 years since the last New York meeting, the membership of the Association has grown from 44,947 to more than 51,000, and there are now 264 organizations affiliated with the AAAS (with action on seven others pending this December) compared with the 214 in 1949. The two journals of the Association have gained in circulation correspondingly; *Science,* with its size and format changed in July 1955, has increased its text coverage more than 50 percent. Some 20 symposium volumes have been published since the sixth New York meeting and nine others are in press and in preparation at this time.

At this year's meeting Section P–Industrial Science, activated in 1951, will hold its sixth program and Section Nd–Dentistry and Section Np–Pharmacy have had full status as independent sections since 1954. In addition to its usual activities, the AAAS has undertaken new responsibilities, including the sponsorship of the International Arid Lands Meet-

ings in New Mexico in 1955. In the current Science Teaching Improvement Program, supported by a grant from the Carnegie Corporation of New York, and the continuation of the Traveling Science Libraries for Small High Schools, financed by the National Science Foundation, the Association has demonstrated its abiding concern for the advancement of science, of science education, and of a better public understanding of the importance and promise of science.

In 7 years, the character of the annual meeting, too, has evolved in line with the thinking of the Arden House Conference. Added to the familiar pattern of many participating societies with their numerous sessions for short reports of current research, the 18 sections of the Association provide strong programs of invited papers in each of the principal fields of science. These symposia, traditionally associated with the AAAS meetings and often aggregating half a thousand speakers, have shown an increased emphasis on important interdisciplinary subjects. The distinguished evening lectures of Sigma Xi, RESA, the National Geographic Society, and Phi Beta Kappa have continued without interruption; the recurrent conferences on academy of science problems, on scientific manpower, and on scientific and technical editorial problems have developed, and meet, a continued interest.

Among the societies participating in 1956 but not present at the 1949 New York meeting are the American Association of Clinical Chemists, American Association of Hospital Consultants, American Astronomical Society, American Documentation Institute, American Psychiatric Association, American Society of Range Management, Association for Computing Machinery, Entomological Society of America, History of Science Society, New York Academy of Sciences, and the Society of General Physiologists. The Society for the Study of Evolution, participating in December 1956, last met with the AAAS in 1949.

Other features of this seventh New York meeting include the two-afternoon general symposium, "Moving frontiers of science," organized by the relatively new standing Committee on AAAS Meetings; the silver anniversary of the AAAS–Gordon Research Conferences—a dinner with an address by Glenn T. Seaborg; the centennial anniversary symposia honoring Sigmund Freud (in the program of the American Philosophical Association) and commemorating Kraepelin (in the program of the American Psychiatric Association); Section G's symposium in honor of the golden anniversary of the Botanical Society of America; and the tenth annual Junior Scientists Assembly—a carefully planned afternoon for high-school science students, with the theme, "What makes a scientist?" The AAAS Science Theater, with its showing of the latest foreign and domestic scientific films, and the 33rd AAAS Annual Exposition of Science and Industry—a large-scale exhibit of the tools and techniques of science—will be well worth the consideration of all who attend.

RAYMOND L. TAYLOR
Associate Administrative Secretary, AAAS

Meeting Notes

■ Progress in preventing health hazards and diseases that range from highway accidents to the common cold will be reviewed by more than 4000 public health specialists at the 84th annual meeting of the American Public Health Association that will take place in Atlantic City, N.J., 12–16 Nov. Organizations scheduled to meet simultaneously include the American School Health Association, Association of Business Management in Public Health, Commissioned Officers Association of the U.S. Public Health Service, Conference for Health Council Work, American Association of Hospital Consultants, Association of Labor-Management Medical Care Program Administrators, American Association of Public Health Physicians, National Association of Sanitarians, Association of Schools of Public Health, American College of Preventive Medicine, and National Citizens Committee for the World Health Organization.

■ The Research Committee of the International Association of Gerontology is organizing symposia for the international congress that will take place at Merano, Italy, 14–19 July 1957. The topics for the symposia will be aging of cells, intercellular matrices, and connective tissues; aging of adaptive mechanisms; genetic studies of aging; and the processes of learning and use of information in aging organisms.

Research workers who will have completed new work in these fields since the last congress and who wish to present papers are asked to communicate with either Dr. A. I. Lansing, Department of Anatomy, University of Pittsburgh, Pittsburgh 13, Pa., or Dr. J. F. Danielli, Department of Zoology, King's College, Strand, London W.C.2, England.

■ The fifth International Conference on Low Temperature Physics and Chemistry will be held at the University of Wisconsin, 26–31 Aug. 1957. The earlier conferences were held at Cambridge, Mass., (M.I.T.) in 1949; Oxford, England, in 1951; Houston, Tex., in 1953; and at Paris, France, in 1955. For information about next year's meeting, write to Joseph R. Dillinger, associate professor of physics at the University of Wisconsin.

Forthcoming Events

October

21–23. American College of Apothecaries, Dallas, Tex. (R. E. Abrams, Hamilton Court, 39th & Chestnut St., Philadelphia 4, Pa.)

21–27. Iberian-Latin American Cong. of Dermatology, 3rd, Mexico City, Mexico. (Centro Dermatológico Pascua, Calle Dr. Garciadiego 21, Mexico 7, D.F., Mexico.)

22–24. American Standards Assoc., 38th annual, New York, N.Y. (ASA, 70 E. 45 St., New York 17.)

22–25. American Soc. for Pharmacology and Experimental Therapeutics, Louisville, Ky. (H. Hodge, Dept. of Pharmacology, Univ. of Rochester, Rochester, N.Y.)

22–26. National Safety Cong., Chicago, Ill. (R. L. Forney, National Safety Council, 425 North Michigan Ave., Chicago 11.)

22–27. Endocrine Soc., 8th annual postgraduate assembly, Houston, Tex. (Office of Dean, Univ. of Texas, Postgraduate School of Medicine, Texas Medical Center, Houston 25.)

22–2. Industrial Forestry Seminar, New Haven, Conn. (E. T. F. Wohlenberg, Industrial Forestry Dept., Yale Univ., New Haven.)

23. American Soc. of Safety Engineers, annual, Chicago, Ill. (J. B. Johnson, ASSE, 425 N. Michigan Ave., Chicago 11.)

24–25. Solid Fuels Conf., 19th annual, sponsored jointly by American Inst. of Mining, Metallurgical and Petroleum Engineers and American Soc. of Mechanical Engineers, Washington, D.C. (ASME, 29 W. 39 St., New York 18.)

25–26. National Soc. of Professional Engineers, White Sulphur Springs, W.Va. (P. H. Robbins, 2029 K St., NW, Washington 6.)

26–27. Kentucky Academy of Science, annual, Richmond, Ky. (Mary E. Wharton, Georgetown College, Georgetown, Ky.)

26–29. American Heart Assoc., annual, scientific sessions, Cincinnati, Ohio. (Medical Director, AHA, 44 E. 23 St., New York 10.)

27. Eastern Psychiatric Research Assoc., New York, N.Y. (T. R. Robie, 676 Park Ave., East Orange, N.J.)

28–1. American Council of Independent Laboratories, 29th meeting, New York, N.Y. (H. M. Dudley, 4302 East-West Highway, Washington 14.)

29–30. American Cancer Soc., scientific session, New York, N.Y. (ACS, Professional Education Section, 521 W. 57 St., New York 19.)

29–30. East Coast Conf. on Aeronautical and Navigational Electronics, 3rd annual, Baltimore, Md. (W. D. Crawford, Westinghouse Electric Corp., Air Arm Div., Friendship International Airport, Baltimore 27.)

29–31. Energy Resources Conf., Denver, Colo. (Energy Resources Conf., c/o Denver Chamber of Commerce, 1301 Welton St., Denver 4.)

29–1. Conference on Climatology sponsored by American Meteorological Soc.,

Asheville, N.C. (K. C. Spengler, 3 Joy St., Boston 8, Mass.)

29–1. Society of Exploration Geophysicists, annual, New Orleans, La. (G. A. Grimm, Tide Water Associated Oil Co., Box 2131, Midland, Tex.)

29–2. Convention on Ferrites, Institution of Electrical Engineers, London, England. (Secretary, IEE, Savoy Place, London, W. C.2.)

31. Society of Vertebrate Paleontology, Minneapolis, Minn. (J. T. Gregory, SVP, Peabody Museum of Natural History, Yale Univ., New Haven, Conn.)

31–1. Western Area Development Conf., 3rd, Phoenix, Ariz. (C. Green, Mountain States Office, Stanford Research Inst., Phoenix.)

31–2. Geological Soc. of America, annual, Minneapolis, Minn. (H. R. Aldrich, GSA, 419 W. 117 St., New York 27.)

31–2. Mineralogical Soc. of America, Minneapolis, Minn. (C. S. Hurlbut, Jr., 12 Geological Museum, Oxford St., Cambridge 38, Mass.)

31–2. Soc. of Economic Geologists, annual, Minneapolis, Minn. (O. N. Rove, 30 E. 42 St., New York 17.)

31–2. Society for Experimental Stress Analysis, annual, Columbus, Ohio (W. M. Murray, Massachusetts Inst. of Technology, Cambridge 39.)

31–3. American Soc. of Tropical Medicine and Hygiene, New Orleans, La. (J. E. Larsh, Jr., School of Public Health, Univ. of North Carolina, Chapel Hill.)

31–3. Gaseous Electronics Conf., 9th annual, Pittsburgh, Pa. (A. V. Phelps, Westinghouse Research Laboratories, Beulah Rd., Pittsburgh 35.)

November

1–2. Society for Applied Spectroscopy, 11th annual, New York, N.Y. (F. M. Biffen, Johns-Manville Research Center, Manville, N.J.)

1–3. Association of Geology Teachers, annual, Chicago, Ill. (C. E. Prouty, Dept. of Geology, Univ. of Pittsburgh, Pittsburgh 13, Pa.)

5–7. Paleontological Soc., annual, Minneapolis, Minn. (H. B. Whittington, Museum of Comparative Zoology, Harvard Univ., Cambridge, Mass.)

6–15. International Grassland Cong., 7th, Palmerston, New Zealand. (S. H. Saxby, P.O. Box 2298, Wellington, New Zealand.)

7–9. Electrical Techniques in Medicine and Biology, 9th annual conf., New York, N.Y. (E. D. Trout, X-Ray Dept., General Electric Co., Milwaukee 1, Wis.)

7–9. Society of Rheology, annual, Pittsburgh, Pa. (W. R. Willets, Titanium Pigment Corp., 99 Hudson St., New York 13.)

8–9. Canadian High Polymer Forum, 7th, Sarnia, Ont. (M. H. Jones, Ontario Research Foundation, 43 Queen's Park, Toronto 5, Ont.)

8–10. Gerontological Soc., annual, Chicago, Ill. (N. W. Shock, Baltimore City Hospitals, Baltimore 24, Md.)

10. Society for the Scientific Study of Religion, fall meeting, Cambridge, Mass. (R. W. Burhoe, American Acad. of Arts and Sciences, Cambridge 36.)

11–12. American Soc. for the Study of Arteriosclerosis, annual, Chicago, Ill. (R. G. Gould, P.O. Box 1663, Los Alamos, N.M.)

11–17. Cardiology, 5th Inter-American cong. of, Havana, Cuba. (I. Chavez, Calzada de la Piedad 300, Mexico, D.F., Mexico.)

12–14. Association of Military Surgeons of the U.S., annual, Washington, D.C. (S. E. Womeldorph, AMSUS, Suite 718, 1726 Eye St., NW, Washington 6.)

12–15. American Petroleum Inst., 36th annual, Chicago, Ill. (API, 50 W. 50 St., New York 20.)

12–16. American Public Health Assoc., 84th annual, Atlantic City, N.J. (R. M. Atwater, 1790 Broadway, New York 19.)

12–16. American Soc. of Agronomy, annual, Cincinnati, Ohio. (L. G. Monthey, 2702 Monroe St., Madison 5, Wis.)

13–15. Historical Development of Physiological Thought, symposium, Brooklyn, N.Y. (E. Goodwin, State Univ. of New York, College of Medicine, Brooklyn 3.)

14–16. Optics and Microwaves, symp., Washington, D.C. (Symp. on Optics and Microwaves, P.O. Box 355, Falls Church, Va.)

14–16. Newer Developments in the Diagnosis and Management of Cancer, symp., Duarte, Calif. (J. Love, Director, Div. of Postgraduate Medical Education, City of Hope Medical Center, Duarte.)

15–16. American Philosophical Soc., Philadelphia, Pa. (APA, 104 S. 5 St., Philadelphia 6.)

15–16. Operations Research Soc. of America, 10th natl., San Francisco, Calif. (T. E. Oberbeck, U.S. Naval Post Graduate School, Monterey, Calif.)

15–16. Society of Technical Writers, jointly with Assoc. of Technical Writers and Editors, New York, N.Y. (S. F. Shapiro, STW, P.O. Box 22, Newton Centre 59, Mass.)

15–17. Acoustical Soc. of America, Los Angeles, Calif. (W. Waterfall, ASA, 57 E. 55 St., New York 22.)

18–25. National Meeting of Surgeons, Mexico City, Mexico. (Intern. Acad. of Proctology, 147–41 Sanford Ave., Flushing, N.Y.)

19–20. Entomological Soc. of America, Eastern Branch, Atlantic City, N.J. (B. F. Driggers, Experiment Station, New Brunswick, N.J.)

22–23. Calder Hall Nuclear Power Station, conf., London, England. (Secretary, British Nuclear Energy Conference, 1–7 Great George St., London, S.W.1.)

22–3. International Cong. of Industrial Chemistry, 29th, Paris, France. (J. Gerard, Société de Chimie Industrielle, 28, rue Saint-Dominique, Paris VII^e^.)

23–24. American Mathematical Soc., Evanston, Ill. (E. G. Begle, 207 Leet Oliver Memorial Hall, Yale Univ., New Haven 11, Conn.)

23–24. American Physical Soc., Chicago, Ill. (K. K. Darrow, APS, Columbia Univ., N.Y. 27.)

23–24. American Soc. of Animal Production, annual, Chicago, Ill. (W. M. Beeson, Dept. of Animal Husbandry, Purdue Univ., W. Lafayette, Ind.)

24. American Ethnological Soc., New York, N.Y. (A. G. James, Hunter College, Bronx 68, N.Y.)

25–30. American Rocket Soc., annual, New York, N.Y. (J. J. Harford, ARS, 29 W. 39 St., New York 18.)

25–30. American Soc. of Mechanical Engineers, annual, New York, N.Y. (C. E. Davies, ASME, 29 W. 39 St., New York 18.)

26–28. American Soc. of Refrigerating Engineers, Boston, Mass. (R. C. Cross, ASRE, 234 Fifth Ave., New York 1.)

26–30. Automation Exposition, 3rd intern., New York, N.Y. (TIAE, Richard Rimbach Associates, Inc., 845-A Ridge Ave., Pittsburgh 12, Pa.)

27–30. American Medical Assoc., clinical, Seattle, Wash. (G. F. Lull, AMA, 535 N. Dearborn St., Chicago 10, Ill.)

27–30. National Chemical Exposition, 9th, Cleveland, Ohio. (American Chemical Soc., 1155 16 St., NW, Washington 6.)

28–30. American College of Cardiology, 5th interim, Pittsburgh, Pa. (P. Reichert, ACC, Empire State Bldg., New York, N.Y.)

28–30. International Conf. on Ozone, 1st, Chicago, Ill. (C. E. Thorp, Armour Research Foundation, 35 W. 33 St., Chicago 16.)

30. American Rheumatism Assoc., Bethesda, Md. (E.F. Hartung, 580 Park Ave., New York, N.Y.)

30–1. Oklahoma Acad. of Science, Stillwater. (D. E. Howell, Entomology Dept., Oklahoma A. & M. College, Stillwater.)

30–1. Tennessee Acad. of Science, Murfreesboro. (D. Caplenor, Dept. of Biology, Peabody College, Nashville 4, Tenn.)

December

2. American Acad. of Dental Medicine, 11th mid-annual, New York, N.Y. (A. Reiner, 114–01 201 St., St. Albans 12, N.Y.)

2–7. Radiological Soc. of North America, Inc., annual, Chicago, Ill. (D. S. Childs, 713 E. Genesee St., Syracuse 2, N.Y.)

5–7. Instrumentation Conf., 2nd, Inst. of Radio Engineers, Atlanta, Ga. (M. D. Prince, Engineering Experiment Station, Georgia Inst. of Technology, Atlanta.)

6–7. American Astronautical Soc., 3rd annual, New York, N.Y. (N. V. Petersen, AAS, 516 Fifth Ave., New York 36.)

6–8. American Phytopathological Soc., annual, Cincinnati, Ohio. (G. S. Pound, Dept. of Plant Pathology, Univ. of Wisconsin, Madison.)

6–9. American Psychoanalytic Assoc., New York, N.Y. (J. N. McVeigh, APA, 36 W. 44 St., New York 36.)

7–11. American Acad. of Optometry, annual, Houston, Tex. (C. C. Koch, 1506 Foshay Tower, Minneapolis 2, Minn.)

9–12. American Inst. of Chemical Engineers, annual, Boston, Mass. (F. J. Van Antwerpen, AICE, 25 W. 45 St., New York 36.)

9–12. American Soc. of Agricultural Engineers, Chicago, Ill. (J. L. Butt, ASAE, St. Joseph, Mich.)

10–12. American Nuclear Soc., winter meeting, Washington, D.C. (ANS, P.O. Box 963, Oak Ridge, Tenn.)

10–12. Eastern Joint Computer Conf., New York, N.Y. (J. R. Weiner, Remington Rand, Inc., 315 Fourth Ave., New York, N.Y.)

13–15. Texas Acad. of Science, annual, Brownwood, Tex. (G. C. Parker, Texas A.&M. College, College Station.)

26–31. American Assoc. for the Advancement of Science, annual, New York, N.Y. (R. L. Taylor, AAAS, 1515 Massachusetts Ave., NW, Washington 5.)

The following 55 meetings are being held in conjunction with the AAAS annual meeting.

AAAS Academy Conference (L. Taylor, West Virginia Univ., Morgantown). 29–30 Dec.

AAAS Cooperative Committee on the Teaching of Science and Mathematics (M. Meister, Bronx High School of Science, New York 68). 27 Dec.

AAAS-Gordon Research Conferences (W. G. Parks, Univ. of Rhode Island, Kingston). 27 Dec.

Alpha Chi Sigma (H. G. Seavey, 30

Church St., Room 340, New York 7). 28 Dec.

Alpha Epsilon Delta (M. L. Moore, 7 Brookside Circle, Bronxville, N.Y.). 29 Dec.

American Assoc. of Clinical Chemists (A. E. Sobel, Jewish Hospital of Brooklyn, Brooklyn 16, N.Y.).

American Assoc. of Hospital Consultants (E. D. Barnett, School of Public Health, Columbia Univ., New York 32.)

American Assoc. of Scientific Workers (R. J. Rutman, 6331 Ross St., Philadelphia 44, Pa.). 29 Dec.

American Astronomical Soc. (J. A. Hynek, Harvard College Observatory, Cambridge 38, Mass.). 26–29 Dec.

American Documentation Inst. (J. Hilsenrath, National Bureau of Standards, Washington 25). 27–29 Dec.

American Educational Research Assoc. (A. G. Wesman, Psychological Corp., 522 Fifth Ave., New York 36). 29 Dec.

American Meteorological Soc. (R. J. Roth, Crop-Hail Insurance Actuarial Assoc., 209 W. Jackson Blvd., Chicago, Ill.). 28 Dec.

American Museum of Natural History (G. Reekie, AMNH, Central Park West at 79 St., New York, N.Y.). 26 Dec.

American Nature Study Soc. (R. L. Weaver, Univ. of Michigan, Ann Arbor). 26–30 Dec.

American Philosophical Assoc., Eastern Div. (J. Wild, Harvard Univ., Cambridge 38, Mass.). 27 Dec.

American Psychiatric Assoc. (B. Pasamanick, Ohio State Univ., Columbus 10). 28–29 Dec.

American Soc. of Hospital Pharmacists (G. E. Archambault, U.S. Public Health Service, Washington 25). 29 Dec.

American Soc. of Range Management (F. G. Renner, Soil Conservation Service, U.S. Dept. of Agriculture, Washington 25). 28 Dec.

American Statistical Assoc. (R. E. Johnson, Western Electric Co., New York 7).

Association for Computing Machinery (J. P. Nash, Univ. of Illinois, Urbana).

Association of American Geographers (P. M. Stern, Conservation Foundation, 30 E. 40 St., New York, N.Y.).

Astronomical League (H. B. Davidson, 812 Park Ave., New York 21.)

Conference on Scientific Editorial Problems (J. G. Adashko, Ford Instrument Co., Long Island City, N.Y.). 26–28 Dec.

Conference on Scientific Manpower (T. J. Mills, National Science Foundation, Washington 25). 26 Dec.

Ecological Soc. of America (M. F. Buell, Rutgers Univ., New Brunswick, N.J.). 26–30 Dec.

Entomological Soc. of America (P. W. Oman, Plant Industry Sta., Beltsville, Md.). 27–30 Dec.

Genetics Soc. of America (A. W. Pollister, Columbia Univ., New York 27). 28 Dec.

History of Science Soc. (Miss P. Kibre, Hunter College, New York, N.Y.). 27–29 Dec.

Institute of Mathematical Statistics (Miss E. Scott, Univ. of California, Berkeley 4).

International Council for Exceptional Children (M. H. Fouracre, Columbia Univ., New York 27). 26 Dec.

International Union for the Study of Social Insects, North American Section (T. C. Schneirla, American Museum of Natural History, Central Park West at 79 St., New York, N.Y.). 26–27 Dec.

Mountain Lake Biological Sta. (B. D. Reynolds, Univ. of Virginia, Charlottesville).

Mycological Soc. of America (L. S. Olive, Columbia Univ., New York 27). 26 Dec.

National Acad. of Economics and Political Science (D. P. Ray, George Washington Univ., Washington, D.C.). 27 Dec.

National Assoc. for Gifted Children (Miss A. F. Isaacs, 409 Clinton Springs Ave., Cincinnati, Ohio).

National Assoc. for Research in Science Teaching (N. Washton, Queens College, Flushing 67, L.I., N.Y.). 27 Dec.

National Assoc. of Biology Teachers (J. Breukelman, State Teachers College, Emporia, Kan.). 26–30 Dec.

National Assoc. of Science Writers (J. E. Pfeiffer, New Hope, Pa.).

National Geographic Soc. (W. R. Gray, NGS, 16 and M Sts., NW, Washington 6). 29 Dec.

National Speleological Soc. (Brother G. Nicholas, LaSalle High School, Cumberland, Md.). 29 Dec.

New York Acad. of Sciences (R. F. Nigrelli, New York Zoological Soc. and M. Kopac, New York Univ., Washington Sq., New York, N.Y.). 29 Dec.

Philosophy of Science Assoc. (C. W. Churchman, Case Inst. of Technology, Cleveland, Ohio). 29–30 Dec.

Pi Gamma Mu (B. H. Williams, Industrial College of the Armed Forces, Washington 25). 26 Dec.

Scientific Research Soc. of America (D. B. Prentice, Yale Univ., New Haven, Conn.). 26–27 Dec.

Sigma Delta Epsilon (C. Chandler, Boyce Thompson Inst. for Plant Research, 1086 N. Broadway, Yonkers 3, N.Y.).

Sigma Pi Sigma (M. W. White, Pennsylvania State Univ., University Park).

Society for the Advancement of Criminology (D. E. J. MacNamara, New York Inst. of Criminology, 2109 Broadway, New York, N.Y.). 29 Dec.

Society for the Advancement of General Systems Theory (L. von Bertalanffy, Mt. Sinai Hospital, Los Angeles 48, Calif.). 29–30 Dec.

Society for the Study of Evolution (H. Lewis, Univ. of California, Los Angeles 24). 27–29 Dec.

Society of General Physiologists (A. Shanes, National Institutes of Health, Bethesda, Md.).

Society of Systematic Zoology (R. E. Blackwelder, Box 500, Victor, N.Y.). 27–30 Dec.

Society of the Sigma Xi (T. T. Holme, Yale Univ., New Haven, Conn.). 27 Dec.

Society of Vertebrate Paleontology, annual (J. T. Gregory, Peabody Museum of Natural History, Yale Univ., New Haven, Conn.). 28–30 Dec.

Torrey Botanical Club (David Keck, New York Botanical Garden, Bronx Park, New York 58). 26–27 Dec.

United Chapters of Phi Beta Kappa (C. Billman, PBK, 1811 Q St., NW, Washington 6). 27 Dec.

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Science Writer for new 516-bed research hospital and basic science research institute. Basic policy clinical and basic science research into the problem of cancer and allied diseases. Salary open. Qualifications: bachelor's degree and 2 years of writing experience. Box 221, SCIENCE. ew 11/23

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APPLICATION FOR HOTEL RESERVATIONS

123rd AAAS MEETING

New York City, December 26-31, 1956

The list of hotels and their rates and the reservation coupon below are for your convenience in making your hotel room reservation in New York. Please send your application, *not* to any hotel directly, but to the AAAS Housing Bureau in New York and thereby avoid delay and confusion. (Members of the American Astronomical Society who wish reservations at uptown hotels should correspond directly with the Hayden Planetarium.) The experienced Housing Bureau will make assignments promptly; a confirmation will be sent you in two weeks or less. **As in any city, single-bedded rooms may become scarce; double rooms for single occupancy cost more; for a lower rate, share a twin-bedded room with a colleague.** Most hotels will place comfortable rollaway beds in rooms or suites at 2.50 or 3.00 per night. Mail your application *now* to secure your first choice of desired accommodations. All requests for reservations must give a definite date and estimated hour of arrival, and also probable date of departure.

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THE RARE EARTHS - A NEW FRONTIER

They offer a rich, new field for research and a challenging industrial potential

a report by LINDSAY

In its restless search for knowledge, science has brought us to the threshold of space, our eyes on the infinity of the universe while we are continuing our investigation of the many mysteries that still exist here on our own planet. One of the richest, most exciting of these virtually unexplored realms lies in that little known group of versatile metals—the rare earths.

There are 15 rare earths—atomic numbers 57 through 71—and together they occupy about .012% of the earth's crust. They are remarkably alike in their chemical behavior because of their atomic structure. The main difference lies in the disposition of the three outermost electrons. The difference is always slight; the heavier rare earth atoms have a smaller radii, hence are denser than the lighter ones.

This characteristic makes separation difficult, but it also makes the rare earths ideal subjects for the study of the magnetic properties of materials and to test various theories of physical chemistry and physics. The rare earths may hold the combination that will unlock many of the secrets of nature.

Industry, too, is turning to the rare earths in a search for materials to improve products and processes. And they have found that the rare earths offer enormous potentials. Already many of these metals are being used in a variety of industrial fields.

Rare earth chloride is a combination of the chlorides of cerium, lanthanum, neodymium and praseodymium with smaller amounts of samarium, gadolinium and less common rare earth chlorides. From this material comes misch metal used in lighter flints and as an additive in many grades of steel. Rare earth chloride also serves in the production of chrome, dentifrices, silk, aluminum, fertilizer and catalysts.

Cerium, most common of the rare earths, is widely used, in its oxide form, as a polishing agent for optical and other forms of glass. Cerium hydrate is an ingredient in the production of the special glass used to view highly radioactive operations.

The rare earths have drying properties that can be useful in the production of better paints. And, neodymium and praseodymium have potential value as colorants in the manufacture of ceramics.

The petroleum industry is investigating the use of rare earths as catalysts in their cracking plants. And this unique group of metals shows promise in catalytic polymerization—a problem in the manufacture of many synthetic fibers and plastics.

Thulium, made radioactive, emits X-rays of proper length and strength for diagnostic use. A pea-sized bit of thulium will last a year as the source of rays in a small, portable X-ray unit . . . a device which would be of great value to physicians and hospitals.

Much of the interest in rare earth and thorium chemicals has been sparked by Lindsay scientists. Since the days of the incandescent gas-mantle lamp, in the last years of the 19th Century, Lindsay has worked and pioneered in this field. Expansion has come as researchers at Lindsay and in science and industry have uncovered new uses for the rare earths. Just recently Lindsay has expanded its ion exchange installation and now has 100 columns in operation at its West Chicago plant for the separation of some of the "rarer" rare earths in commercial quantities and in purities up to 99.99%.

If you think there is even a remote possibility that the rare earths might have significant applications in your industry, you may find it worthwhile to talk with our technical people. The data obtained through our years of research is available to you and we can supply you with rare earths in quantities from a gram to a carload.

PLEASE ADDRESS INQUIRIES TO:

LINDSAY CHEMICAL COMPANY

280 ANN STREET, WEST CHICAGO, ILLINOIS